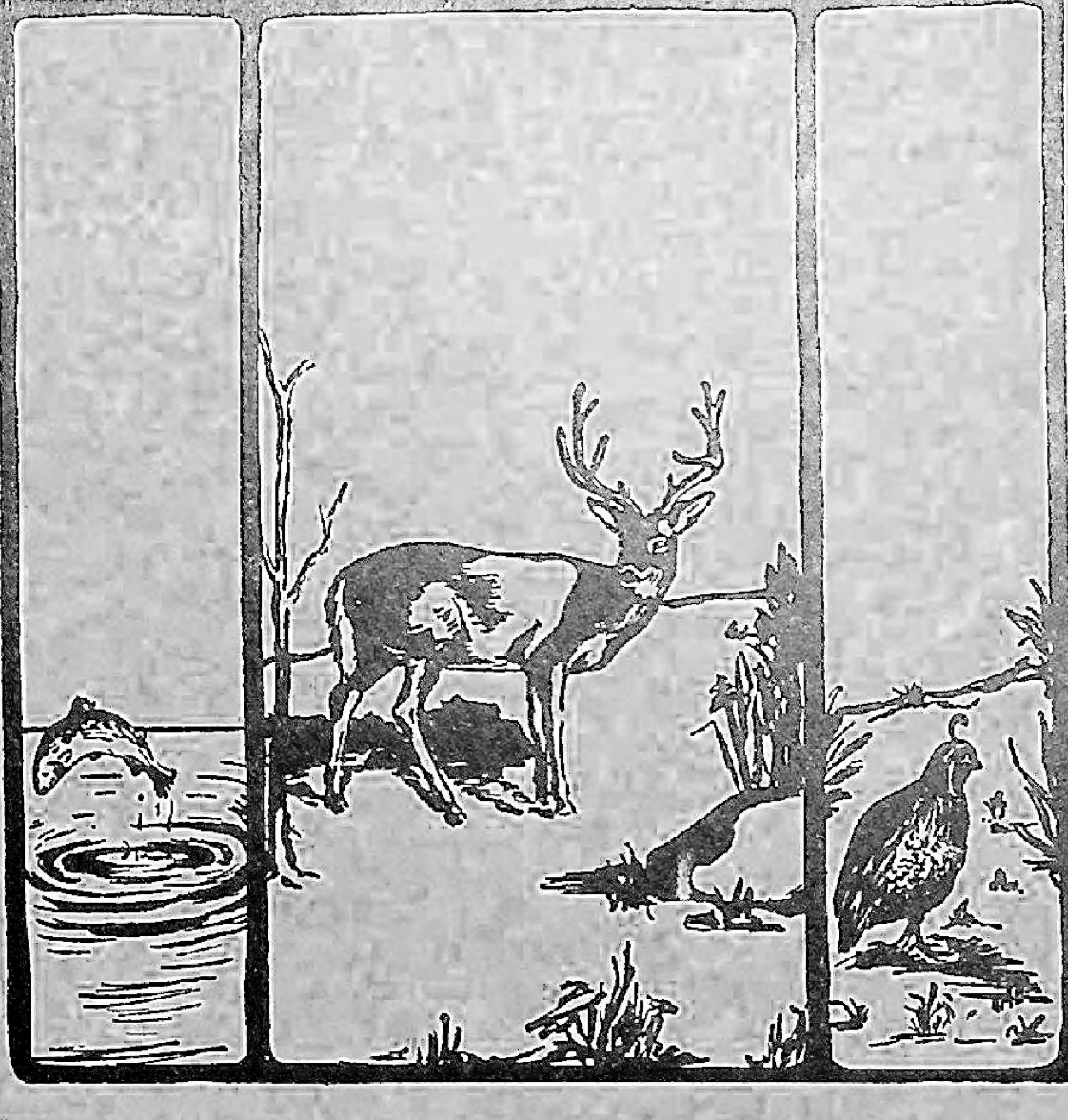
CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

Volume 26 San Francisco, January, 1940 Number 1



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CALIFORNIA FISH AND GAME is a publication devoted to the conservation of wild life. It is published quarterly by the California Division of Fish and Game. All material for publication should be sent to Richard S. Croker, editor, California Division of Fish and Game, Terminal Island, California.

HYDRAULIC MINING AND DEBRIS DAMS IN RELATION TO FISH LIFE IN THE AMERICAN AND YUBA RIVERS OF CALIFORNIA[1]

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and

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Introduction

During the summer and fall of 1938, a biological survey was made in the lower American and Yuba river basins in order to determine the effect on fish life of renewed hydraulic mining in these basins and the attendant construction of debris dams, built to collect the gravel, sand and silt washed down from the mines. The survey was financed by the Engineer Corps of the U. S. War Department and supervised by the Stanford University office of the Bureau of Fisheries, U. S. Department of the Interior. The present paper is a summary of a report submitted to the U. S. District Engineer's Office at Sacramento, California.[2]

Acknowledgments

The authors wish to express their appreciation to Colonel L. B. Chambers and Major W. E. Harris of the U. S. District Engineer's Office in Sacramento for administrative assistance given to the survey, to Dr. P. R. Needham of the U. S. Bureau of Fisheries for advice and criticism, and to Mr. A. C. Taft, Mr. John Spencer and Mr. Brian Curtis of the California Division of Fish and Game for material used in this paper.

The Field Survey

Field work started on July 1, 1938, and was continued until November 3 by a survey party of four. After the latter date and until May 1, 1939, the senior author made occasional observations in connection with the problem. Equipment for the survey, including two Chevrolet pick-up trucks and camping and scientific supplies, was furnished by the U. S. Engineer's Office at Sacramento. In addition some items were supplied by the U. S. Bureau of Fisheries.

Methods of Procedure

In general the standard procedure for stream surveys as developed by the U. S. Bureau of Fisheries (Davis, 1938) was followed and the

[1] Submitted for publication, November, 1939. Published by permission of the U. S. Bureau of Fisheries and the U. S. District Engineer's Office.

[2] "A biological study of the effect of mining debris dams and hydraulic mining on fish life in the Yuba and American rivers in California," by F. H. Sumner and Osgood R. Smith; Stanford University, California, 1939 (mimeo.).

data recorded on the U. S. Bureau of Fisheries Stream Survey blank form (Form 11-11628).

The streams were studied as to average width, depth, flow, temperature, bottom types, aquatic vegetation, fish foods, barriers, diversions, fishes present, degree fished, spawning areas, and other characteristics.

FIG. 1. Hydraulic-mining operations at Lost Camp Mine, Blue Canyon, North Fork of North Fork of American River. April 5, 1939.

The Problem

Hydraulic mining for gold was carried on extensively in the Yuba and American river basins, as well as on other California streams, during the middle decades of the last century. The process consisted in washing down ancient Tertiary gravel deposits by directing a powerful jet of water against a bank (see Fig. 1). It has been estimated by Gilbert (1917) that between the years 1849 and 1909, hydraulic mining moved 684,000,000 cubic yards of gravel and other debris in the Yuba River basin, and 257,000,000 cubic yards in the American River basin. Most of this gravel was washed directly into the streams and rivers, with the result that it covered much good agricultural land along the lower Yuba River and threatened to fill in the navigable channel of the Sacramento River. Legal injunctions closed most of the mines by 1884. Hydraulic mining may be carried on in conformity to California law only if some means is provided to settle out the silt and gravel washed from the mines. Consequently, ways and means of reopening the mines without conflicting with the law, or with the interests of agriculture and navigation have been sought. For this purpose Congress in 1893 passed the Caminetti Act[3] creating the California Debris Commission. The Commission, under the Debris Control Project, has planned several dams to impound hydraulic mining debris. Although other dams are in prospect, this study has con-

[3] "An act to create the California Debris Commission and regulate hydraulic mining in the State of California," approved March 1, 1893; amended, 1907, 1934, 1938.

cerned itself only with the three planned for the American and Yuba rivers.

The largest of the three debris dams is to be 237 feet high and is being built at the Upper Narrows on the Yuba River, about 3 miles northeast of Smartsville (see Fig. 2). Footings for the dam were being excavated on April 6, 1939, and completion of the construction is expected in December, 1940. The reservoir behind it will be 9 miles long, with a capacity of about 74,000 acre feet of water. Debris will be discharged into the reservoir from the Middle and South forks.

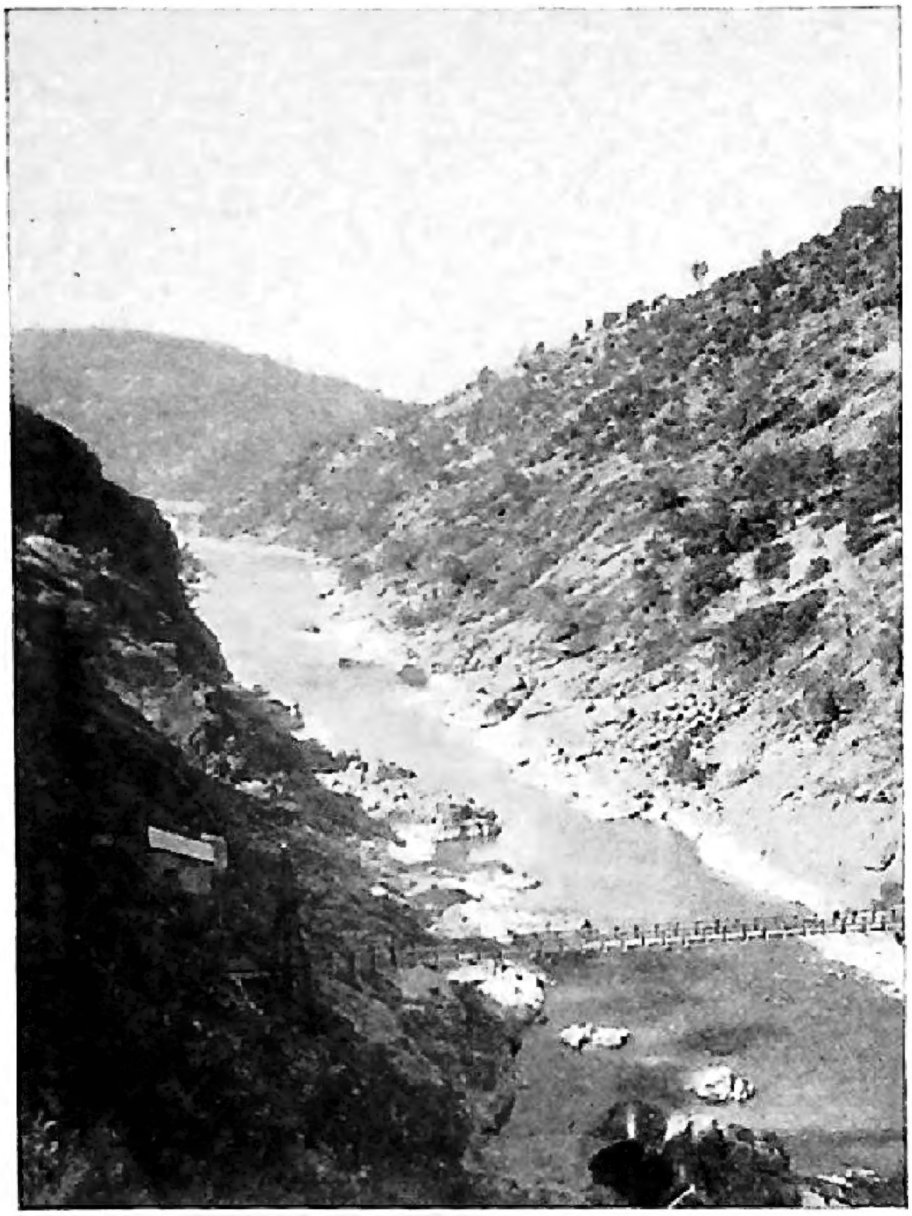

FIG. 2. Yuba River, downstream from Narrows Debris Dam site. August 26, 1938.

On the North Yuba, the Bullards Bar Dam has provided mining debris storage since 1921.

On the North Fork of the American River, about 2 miles above the Middle Fork junction, and about 4 miles northeast of Auburn, a debris dam was completed in April, 1939 (see Fig. 3). It is approximately 140 feet high and impounds a reservoir about 5½ miles long with a capacity of about 12,500 acre feet of water.

The site of the proposed dam on the Middle Fork of the American River is in Ruck-a-Chucky Canyon about 10 miles above the junction

of the North and Middle forks. This dam will be about 140 feet high, with a reservoir about 6 miles long, which will have a capacity of approximately 12,700 acre feet of water.

No hydraulic mining debris will enter the South Fork of the American River, because of the scarcity of gold-bearing gravels in its basin.

If all water available for hydraulic mining is used, it is estimated that in about twenty years sufficient gravel will have been washed out of hydraulic pits to fill the debris reservoirs. Hydraulic mining above the debris dams in such cases will cease at the end of twenty years.

FIG. 3. North Fork Debris Dam showing spill shortly after completion. April 5, 1939.

The debris dams present two fisheries problems. In the first place they are high dams which will block any possible steelhead or salmon runs, because the lowest dam is twice the height considered practical for fish ladders. In the second place the debris dams, unlike other dams, are built for the sole purpose of allowing gravel and silt to be washed into the streams above them, and this silt will affect both resident and migrant fish.

It should be emphasized that everything said in this article concerning the probable effects of debris dams on migratory fishes will apply as well to the dams projected for the Yuba and American rivers under the State Water Plan (California Division of Water Resources, Bulletin 26, 1931). Some of the dams contemplated by the State Plan are higher and located farther downstream than the debris control dams, and therefore would be a greater menace to migratory fish life.

Physical Features

The American River flows about 110 miles west from an altitude of 8,500-9,000 feet in the central Sierra Nevada into the Sacramento River at Sacramento. Its North, Middle and South forks are respectively about 85, 60 and 60 miles long. The main stream from near

Folsom to Sacramento adds about 28 miles to the total length of the stream.

The Yuba River basin is north of the American River basin, and contiguous with its uppermost part, being separated from it at lower elevations by the Bear River and smaller intermittent foothill streams (see map, Fig. 10). The Yuba's three branches, the North, Middle and South forks, arise at an elevation of about 8,000 feet; their respective lengths are about 60, 60 and 63 miles. The main stream flows into the Feather River at Marysville, 30 miles below the mouth of the South Fork.

The upper parts of both rivers drain mountainous areas which are partly forested and partly bare granite. At median elevations, dense coniferous forests prevail, while the foothills below are only sparsely wooded. In a north and south direction across the Yuba and American river basins stretch the disjointed remains of ancient Tertiary river channels whose gravel has contributed a large part of the gold mined in California. The gravel deposits marking these channels lie on top of the ridges dividing the Yuba and American river forks. The present rivers have cut through these deposits and formed deep rugged canyons.

History of Mining and Dams in the Yuba and American River Basins and Their Effects on Fishes

In order that a fair appraisal be made of the damage to fish life to be caused by debris dams and renewed hydraulic mining in the Yuba and American river basins, it is first necessary to consider the effects of past mining and previously constructed dams in the areas concerned.

No information on fishes in the Yuba and American rivers could be found in early accounts of mining along these streams. However, we may deduce what certain mining practices did to the fish population. The muddying of streams by the earliest placer operations probably discouraged spawning by salmon. This will be considered at greater length below. In the second stage of mining operations, long stretches of the American and Yuba rivers were carried through wooden flumes so that the stream bottom could be mined. Undoubtedly this practice seriously interfered with salmon spawning migrations. The flumes were often washed out by spring high water; hence, steelhead trout had a better chance to complete their runs.

That the later hydraulic mining was a detriment to the salmon population was evidently the belief of the Commissioners of Fisheries of California, who in their report[4] for the years 1870 and 1871 state: "Formerly salmon were plenty and largely caught by the Indians in the Feather River, in the Yuba, and in the American; but of late years they have ceased to visit these rivers. It is not because the waters of these rivers are muddy * * * They will pass through muddy water, if beyond they find clear water and clean gravelly bottoms. The gravel beds that formerly existed in these streams are now covered with a deposit of mud, washed down from the mines; and on this the eggs of the salmon will not hatch."

[4] Reproduced in California Fish and Game, vol. 19, no. 1, pp. 41-56, 1933.

In more recent years, hard-rock mining has succeeded hydraulic mining in importance. In this process water containing dissolved cyanide is used in recovering gold from finely ground ore. Though the State Fish and Game Code prohibits pollution of streams by chemicals or other materials harmful to aquatic life, poisonous mine tailings have been washed directly into streams where they have killed fish and fish food (see Fig. 4). This pollution was often observed during the present survey, particularly in Poorman Creek on the South Yuba. Here the stream bottom was devoid of aquatic insects two miles below the Spanish Mine.

Dams on the Yuba and American rivers have blocked and hindered salmon and steelhead trout spawning runs for many years, thus contributing greatly to the reduction in the numbers of these fishes.

On the Yuba River, the Daguerre Point Dam, about 10 miles above its mouth, has almost completely blocked king salmon runs since

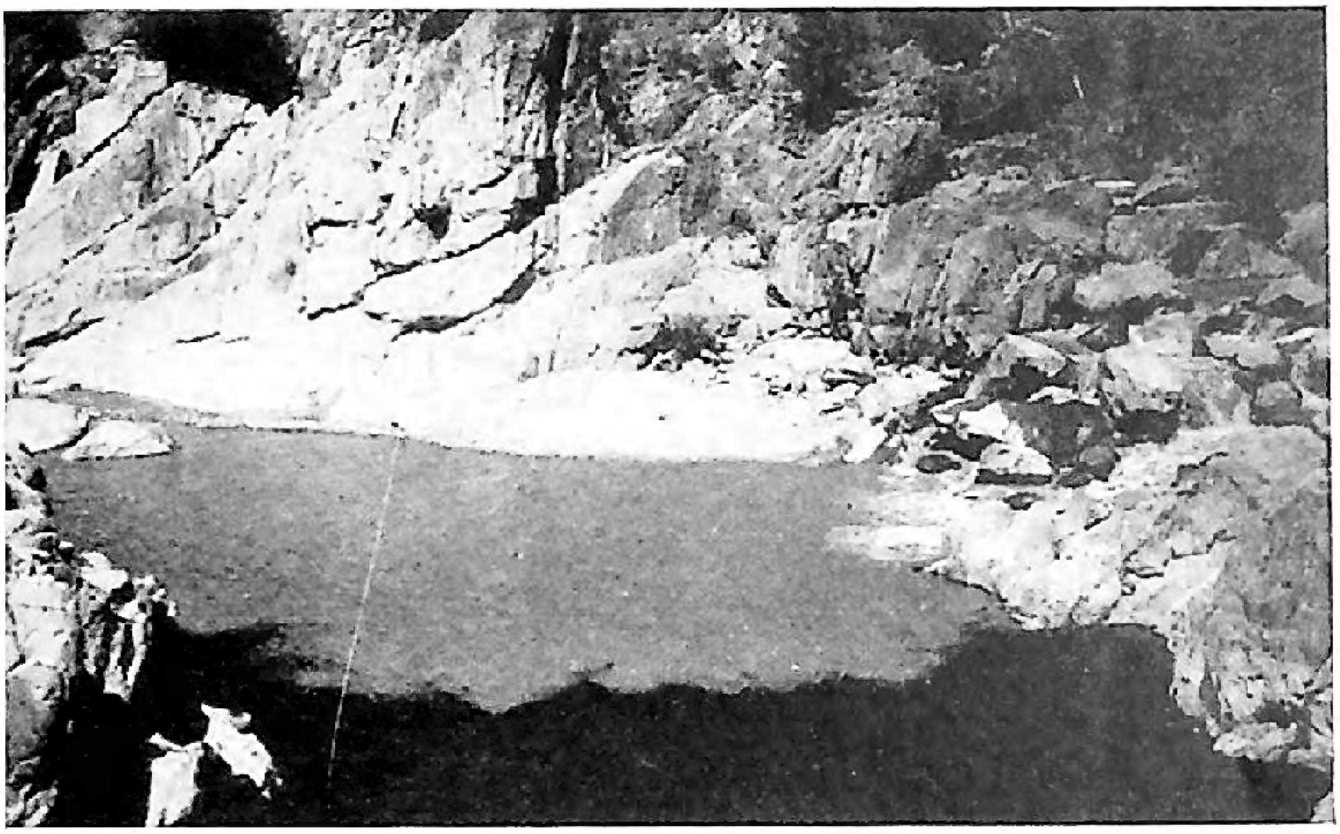

FIG. 4. North Fork of the American River showing entrance of mine slickens from the North Fork of the North Fork. Note distinct line between clear water in the main river, foreground, and polluted water in tributary, right center, which has discolored entire stream. August 9, 1938.

its construction in 1910. Moreover it had a predecessor, Barrier No. 1, which was constructed in 1904-05 at a point 4½ miles farther upstream, and destroyed by floods in 1907. Both structures were part of a program of the California Debris Commission to impound a portion of the gravels washed down from canyon deposits farther upstream and to prevent flooding of bottom lands. These deposits had been slowly washed downstream since the closing of hydraulic mines in the 1880's.

Clark (1929) speaks of "two fishways around this (Daguerre Point) dam, one for low water and the other for high water," and that they "were destroyed by floods in the winter of 1927-28." A rather ineffectual fishway consisting of a channel cut through bed rock

to the lower crest of the dam at its south end has been present for many years. That few fish have been able to use it (and the earlier fishways) is testified to by the almost universal belief among local residents that at present no fish ever come above the dam. It was also reported that heavy runs of salmon occurred in Dry Creek and Deer Creek above the Daguerre Point Dam before its construction, but there are few, if any, there now. Considerable numbers of salmon did, however, get over the Daguerre Point Dam in some years (probably those in which high water coincided with the runs) for, when Bullard's Bar Dam on the North Fork was being constructed (1921-24), so many salmon congregated and died below it that they had to be burned. Steelhead trout make their spawning run during the spring high water, and so they are better able to get over the dam.

FIG. 5. Daguerre Point Dam showing the new fish ladder at south end. Arrow indicates entrance-channel to fish ladder. April 6, 1939.

An improved fish ladder was installed by the U. S. Engineers at the south end of the Daguerre Point Dam during the fall of 1938 (see Fig. 5). From October 24 to December 17, 64 salmon were counted over the fish ladder. The count started after the beginning of the run and was made for only 8 hours a day; hence probably many more fish went up than were tallied, and undoubtedly more would have used the ladder had its approaches been more accessible. The fact remains that the salmon run at this point is now very small. It must be kept in mind that salmon tend to return to the place where they were spawned, and that, since few have been able to get above the dam in past years, a small run might be expected.

On the American River, the Folsom Dam (see Fig. 6), about 27 miles above its mouth, was begun in 1866 and completed in 1895. It is of masonry and is about 68 feet high. A fishway was first built over it in 1919. Spawning runs of king salmon and steelhead trout were thus completely halted for the 24 years between 1895 and 1919. Moreover, the fishway when constructed was ineffective, at least for salmon, and was not remodelled for 12 years—until 1931. Thus 36

years would be more correct as the period during which salmon were virtually excluded from the upper stream. During the fall of 1938, 328 salmon were counted over the fishway between October 4 and December 30, in which period there were 5 days when no water ran through the fishway, and 9 other days when no count was made. It is apparent then that the spawning runs have been making some sort of a recovery after their long interruption.

Fig. 6. Folsom Dam, American River, at high water; fish ladder at left. March, 1938.

Salmon runs are also partially blocked by another barrier, the North Fork Ditch Company's dam, about 15 miles farther upstream near Auburn. This 16-foot dam was built in 1899. A simple rock-chute fishway was built in 1912, but since it lacks adequate resting space, salmon can not make much use of it. During spring high water, steelhead are reported to get over the dam itself. One salmon was seen above the dam at the junction of the North and Middle forks in the fall of 1938, but none was reported by engineers and workmen at the North Fork Debris Dam, then under construction.

The blocking of spawning runs of fishes by dams is paralleled by the loss of young salmon and steelhead in unscreened diversions. The Hallwood Irrigation District diversion at Daguerre Point Dam lacks a fish screen, as does also the previously mentioned large diversion at Folsom Dam supplying power turbines at Folsom Penitentiary and at the Folsom Power House of the Pacific Gas and Electric Company. Of course the number of young fish lost in irrigation ditches and presumably killed by power turbines is conditioned by the number of adult fish spawning above the diversions. If few adult fish get over the dams, few will come down, and vice versa. Many dead and

spawned-out adult salmon were seen on the trash rack of the Folsom Power House during the latter part of the 1938 fall spawning period, and adult steelhead, on their way back to the ocean after spawning, were reported there in April, 1939. The North Fork Ditch has a parallel-bar trash rack which is inadequate for the exclusion of small downstream migrants.

Distribution of Fishes in Relation to Hydraulic Mining

During the course of the field investigations, collections of fishes were made in order that the probable geographical relation between sport fishing areas and hydraulic mining areas might be determined. The principal concern is the lower limits on the main streams at which trout are found in numbers sufficient to attract angling, in relation to the upper limits of hydraulic mining.

In the Middle Fork of the Yuba River, the highest point at which hydraulic mining debris will enter is the mouth of Wolf Creek. There are said to be a few trout near this point, and some were collected about 9 miles above it, but most of the angling in the Middle Fork is done above Milton Lake Reservoir, still farther upstream.

The South Fork of the Yuba is not considered an angling stream in its 24 miles below the mouth of Poorman Creek, where slickens of pulverized rock from the Spanish Mine turn the river a muddy grey when it is operating. The highest point at which hydraulic mining debris will enter this stream is from Scotchman Creek near Washington (3 miles above Poorman Creek). Trout have been planted annually in recent years between Washington and Lake Spaulding, but the greater part of the stocking is done above this lake. Several trout were collected near the mouth of Fall Creek, between Scotchman Creek and Lake Spaulding.

The North Fork of the North Fork of the American River is the highest tributary on that fork from which mining debris will enter. Relatively little angling is done below Euchre Bar near the North Fork of the North Fork. Trout have been planted in the North Fork near Auburn, but nothing has been seen of them since, according to reports.

The lowest point on the Middle Fork of the American River at which trout were found was just below the mouth of Brushy Creek near Ralston. Since they were abundant here, their distribution probably extends downstream some distance. The upper limit of hydraulic mining will surely extend to Volcano Creek and probably to Duncan Creek. Little angling, however, is done below Chipmunk Creek, which is about 2 miles above Duncan Creek. Fish stocking in the Middle Fork within recent years has been concentrated on French Meadows (see Fig. 7), about 7 miles above Duncan Creek.

It is apparent from the foregoing that most angling in the main forks of both rivers is done above the upper limits of hydraulic mining, from which it follows that the entrance of hydraulic mining debris into the main forks will have little effect on existing trout fishing in these forks.

Trout were found in several tributaries of the main forks of the Yuba and American rivers. Some of these tributaries are esteemed

FIG. 7. Middle Fork of the American River at French Meadows. A typical good angling stream above hydraulic-mining areas. August 3, 1938.

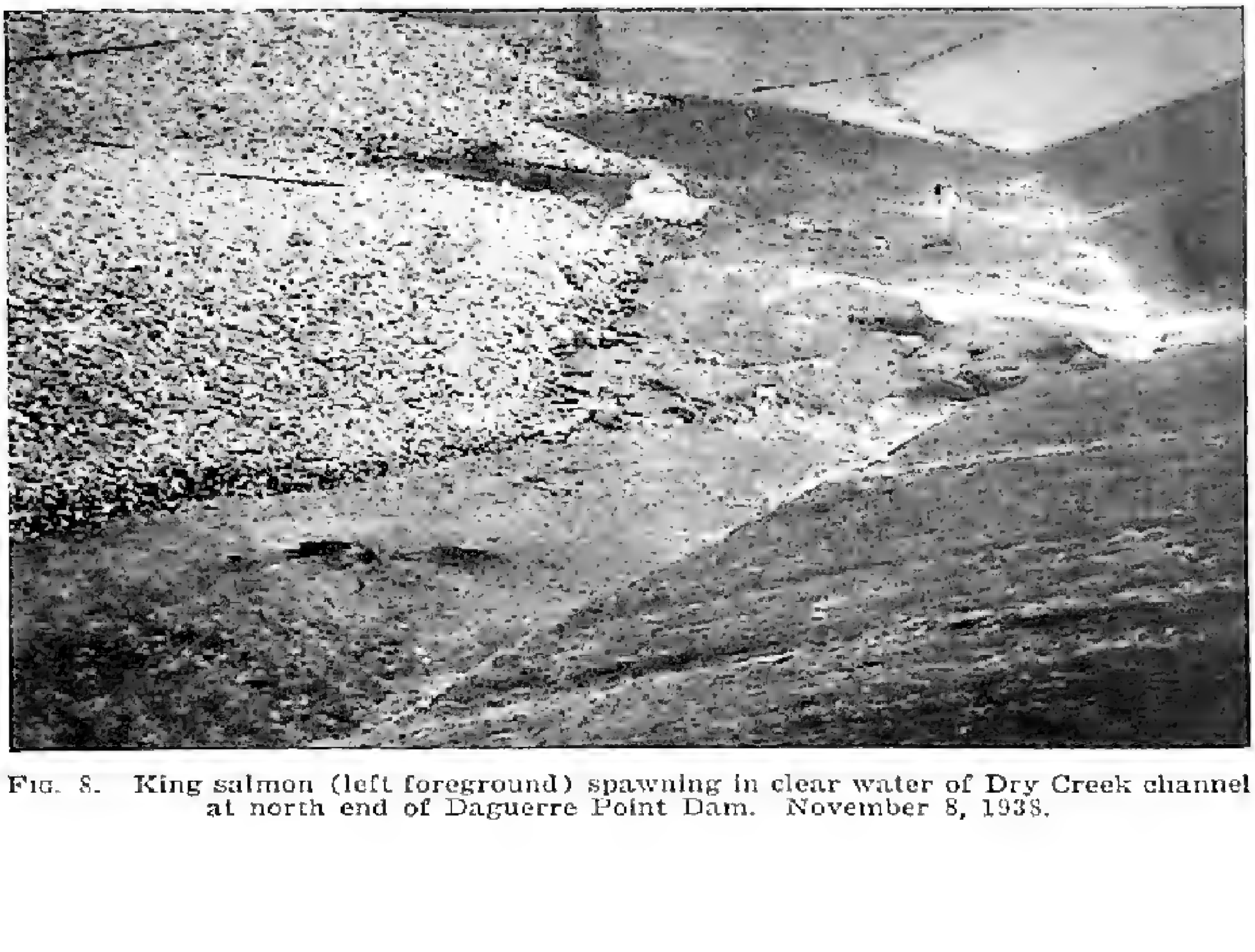

FIG. 8. King salmon (left foreground) spawning in clear water of Dry Creek channel at north end of Daguerre Point Dam. November 8, 1938.

for early season angling before the upper areas are accessible. There are about 130 miles of fishable tributaries of which about 25 per cent will presumably be rendered unfit for angling when hydraulic mining is resumed. The figures here used are based on the assumption that hydraulic mining will extend only to Volcano Creek on the Middle Fork of the American. This reckoning excludes the extensive Rubicon River system which will not be affected.

Records of Salmon and Other Fishes

In the Yuba River, king salmon were seen only in the lower river. Indications of spawning were noted near the Marysville city limits. A few salmon were seen spawning in a clear seepage stream about a mile below Daguerre Point Dam, and many just below the dam (see Fig. 8).

FIG. 9. King salmon redds (lighter bottom areas), North Fork of American River near Knickerbocker Creek and North Fork Ditch Company's dam. November 17, 1938.

Spawning salmon were observed in the main American River beneath the Fair Oaks Bridge, about 10 miles above the river's mouth, and at Folsom; in the North Fork, about a fourth of a mile below the North Fork Ditch Company's dam (see Fig. 9); and in the South Fork, near Mormon Island, about 2 miles above its mouth. Salmon were also seen trying to jump the North Fork Ditch Company's dam and, on the South Fork, the Salmon Falls.

Of the so-called rough fishes present, the Sacramento pike (*Ptychocheilus grandis*) and the hardhead (*Mylopharodon conocephalus*) were among the most widespread in both streams. Their upper distribution coincides roughly with the lower limits for trout. To what extent the muddying of streams tends to encourage them at the expense of trout is not definitely known. In so far as muddy water absorbs more of the sun's heat than clear water, trout are discouraged and the distribution of these minnows is extended. It is known as well that Sacramento pike are predators on trout.

The striped bass and shad, two introduced species, are springtime visitors to the Yuba and American rivers below the lowest dams. The former may possibly cause some loss among young salmon and trout on their seaward migrations.

Other species of fishes found are noted in the appended list (see p. 21), together with species presumed to occur in the American and Yuba rivers on the basis of collections recorded by Evermann and Clark (1931).

Effect of Debris Dams on Fishes

The dams previously discussed, with the exception of the Bullard's Bar Dam on the North Yuba, are all below the debris dam sites. It is apparent then that a consideration of the effect of debris dams on salmon and steelhead involves a consideration of potential runs above the lower dams as well as present runs. Since present runs are almost negligible, the question then becomes: in the light of our present knowledge, what sort of run could be built up if (1) conditions at pre-existing dams were made and kept favorable to the passage of upstream-migrating spawners and downstream-migrating young, (2) all mining pollution were excluded, and (3) adequate protection from poachers were given the spawning fish? Much greater runs are potentially possible judging by the numbers of salmon counted over dams in other streams. For instance, a count [5] made on the upper Sacramento River at the Anderson-Cottonwood Dam at Redding during the fall of 1938 disclosed 20,000 fish (13,885 counted, remainder estimated) going into spawning streams with a total length of about 214 miles and an average flow of 5,501 cubic feet per second. On a proportional basis, the American River, with about 125 miles of spawning stream [6] and an average of mean monthly flows equal to 4,050 c. f. s. should support a run of 11,500-14,500 salmon; and the Yuba River, with a useful length of about 95 miles, and an average of mean monthly flows equalling 3,330 c. f. s., could receive an estimated 8,500-12,000 fish. However, only a fraction of the available spawning areas in the upper Sacramento River were used by the 1938 run; hence, the potential run into the Yuba and American rivers might be much greater than the above figures indicate. This assumption is borne out by estimates of spawning areas in these rivers.

Spawning areas in the Yuba River (below Daguerre Point Dam) and in the American River (below Volcano Creek on the Middle Fork, the Forest Hill Bridge on the North Fork, and Salmon Falls on the South Fork) were estimated at 3.2 per cent of the total area in these sections. This estimate was reduced to 2 per cent to give a more conservative figure. The amount of stream required by a pair of salmon to make their nest or redd (see Fig. 9) was taken as 20 square feet.[7] On the basis of these figures, the Yuba could support a run of approximately 60,000 salmon and the American could provide spawning space for 129,000 salmon.

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[5] From unpublished data of U. S. Bureau of Reclamation.

[6] In the absence of positive knowledge, spawning limits were taken arbitrarily as follows. Yuba River: Middle Fork, to its South Fork; South Fork, to Humbug Creek (impassable falls are reported a short distance above both points); North Fork, none. American River: North Fork, to its North Fork; Middle Fork, to Duncan Creek; South Fork, to Salmon Falls.

[7] From estimates of spawning areas by H. A. Hanson (unpublished).

It may reasonably be asserted therefore, that, assuming the success of efforts to make and keep existing fishways operative and to protect spawning runs from poachers, the impassable debris dams will considerably restrict the spawning area in these two streams. From calculations based on stream length, it has been determined that about 74 per cent of the spawning area on the Yuba will be cut off and approximately 44 per cent on the American River. But since spawning areas above the debris dam sites were found to be inferior to those below, the amounts which will be cut off by the dams may actually be somewhat less than these figures indicate. What size of steelhead run would be cut off by the debris dams is not known since steelhead trout are difficult to count over the lower dams during spring high water. However, their runs will be damaged more completely than runs of salmon, since they do not, like the salmon, spawn in the lower river, but seek the higher tributaries. The loss of young steelhead (or rainbow trout) must also be considered since they contribute to the sport angling of the upper river before migrating to the sea.

The reservoirs behind the debris dams will not flood any areas now fished extensively. On the other hand, they may be capable of providing some good angling for several years, when water conditions permit. During most of the hydraulic mining year, the reservoirs probably will be muddy; but the report of the Hydraulic Mining Commission (1927, p. 65) states that, "In all cases there are several summer months when piping [to mines] stops for lack of water." During these months, then, the streams within the hydraulic mining area should be clear and the debris reservoirs suitable for angling, provided that fish life has been able meanwhile to survive and reproduce.

It was thought that the upper ends of the reservoirs might settle out enough of the river's suspended load to leave their lower ends fairly clear. However, this did not prove true, at least in the case of the North Fork Debris Dam. When observed on April 6, 1939, its spill was an opaque yellow-brown color from mud which evidently originated at the Lost Camp Hydraulic Mine near Blue Canyon. Since the Middle Fork was clear on the same date, the discoloration of the North Fork was evidently not due to natural erosion consequent on high spring run-off. The river seemed just as muddy at Folsom, 22 miles below, as at the debris dam.

If the debris reservoirs are incapable of settling out fine mud, as appears to be the case, then spawning by salmon below the dams may persist at a low level or even decrease, unless runs can be built up in such suitable tributaries as the South Fork of the American River and Dry Creek on the Yuba River.

Effect of Mining Debris on Fishes

After the resumption of hydraulic mining, the rivers will carry a heavy load of silt. Therefore, observations were made of the effect of silty or muddy water on fishes. A good opportunity for this was offered by the presence of spawning salmon below the Daguerre Point Dam on the Yuba River. The greater part of the water passing over this dam is from the Yuba River itself, which during the fall of 1938 was generally muddy from mining operations of various types. However, a chan-

nel from Dry Creek passes over the north end of the dam and continues for a distance of about 200 yards below, separated from the Yuba River by a bed rock outcrop and a gravel bar. The Dry Creek flow was, in contrast to the Yuba, quite clear. Its volume was about 1/25th the volume of the main river. Salmon were observed spawning in the muddy Yuba water, but a much greater number in proportion to available area spawned in the clear water from Dry Creek (see Fig. 8). The concentration of salmon in Dry Creek was such that previously constructed redds were torn up. Except for the muddy water, both parts of the river bed seemed to be equally suitable for spawning.

About a mile below Daguerre Point, a clear flow of water seeps from large gravel piles left by gold dredges. Here again, salmon were attracted in more conspicuous numbers than to nearby spawning areas in the main river. More testimony to the significance of these small clear streams is provided by the fact that they are known to poachers as the best places at which to find salmon. During the fish count, men were often seen at the north (Dry Creek) end of the Daguerre Point Dam with gaffs, spears and clubs.

Some will object that the largest runs of salmon occur after a river has risen and become muddy. This is not denied, but observations elsewhere indicate that salmon, once in a stream, normally await clearing of its water before actually spawning. F. A. Davidson of the U. S. Bureau of Fisheries Laboratory at Seattle, Washington, informed the writers that he saw salmon in streams of the Bristol Bay area, Alaska, which carried a load of glacial silt, fully as heavy as that produced by hydraulic mining. While the salmon ascended these streams, they always entered clear, side tributaries to spawn.

With regard to the mortality of fish eggs in a muddy stream, Hobbs (1937) found that in New Zealand streams the mortality of trout eggs was greatest in redds containing the largest proportion of fine materials (under 0.03 inch in diameter). Shapovalov (1937) also concludes, from experiments with steelhead eggs, that silting can be detrimental to the survival of eggs in the gravel. Ward (1938) says that "Erosion silt in some streams has been found to cover nests and spawning grounds with a blanket such that the bottom fauna was killed and eggs also suffocated in nests." Other testimony to the deleterious effect of muddy water on fishes is furnished by Ellis (1937), who remarks that "Parts of some streams, as the Yellowstone and Missouri —draining areas in which natural erosion has been proceeding rapidly—have been muddy with their loads of erosion silt since before the earliest records by man and have as a result limited fish faunae."

Ward (1938) cites an experiment by L. E. Griffin which seems to prove, according to the "California Mining Journal" of October, 1938, that "young fish thrive on mud." In the experiments, cutthroat trout and king salmon fingerlings were held in hatchery troughs, one containing clear water and the other muddy water. With both species survival was greater in muddy than in clear water. However, in both experiments, the heaviest loss occurred in the first four days of the experiment. Griffin attributed the heavy loss to the fact that the fish in clear water were able to see better, and were so frightened by activity near the tanks that they dashed against the walls and injured themselves. Whatever the cause, a mortality as large as 46 out of 75 must

be attributed to some unusual factor which would not affect normal wild fish in clear streams. Consequently it would be better to compare survivals after the fourth day. When this is done, it appears that the salmon mortality was higher in muddy water, 12.2 per cent to be exact, and only 6.9 per cent in clear. It was the other way around with the cutthroat trout, whose mortality was 42.9 per cent in muddy water and 85.7 per cent in clear water. Both these mortalities for cutthroat are so abnormally high and the number of fish so small (50 and 40 at the start) that the experiment has little significance. The only conclusion which can be drawn from these two experiments is that salmon and trout fingerlings can survive for a few weeks in muddy water. But

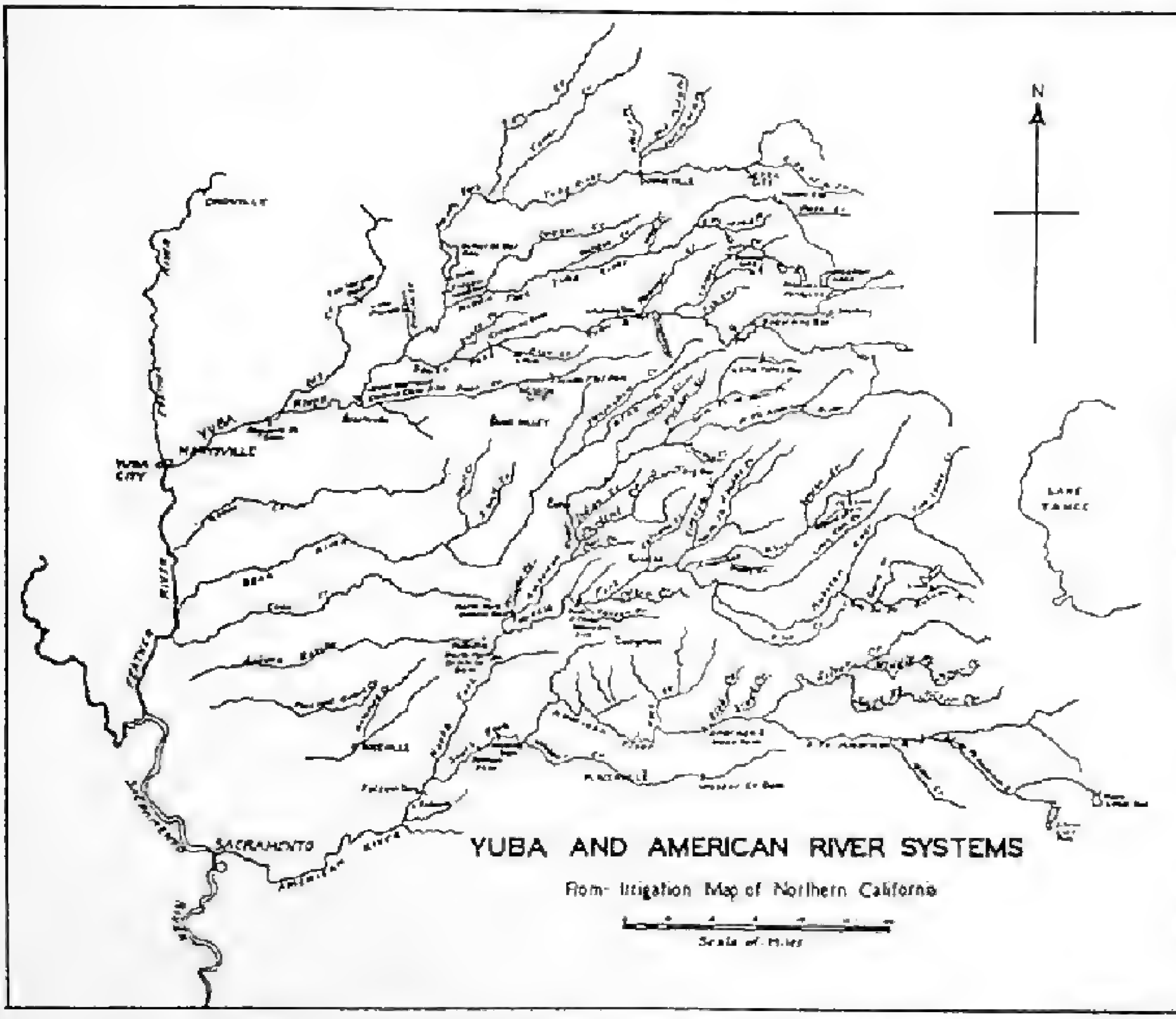

FIG. 10. Map of Yuba and American River systems.

the fact that fish can find artificial food in muddy water would not help them much in streams where silted water has smothered out natural food organisms. Griffin himself stated practically this same thing, but unfortunately he presented his data in such a way that it can easily be misinterpreted, as has already been done.

Natural Erosion

The run-off from normal rains and spring thaws carries silt, sand, and larger particles into streams. This natural silt is much like hydraulic mining debris, and in exceptional years it may muddy some

streams to such a degree that salmon spawning is relatively unsuccessful. Ordinarily streams are relatively clear when salmon spawn and while the eggs are in the gravel. If hydraulic mining debris entered the stream only during the same part of the year in which natural debris were present, there would be less chance that it would damage fish life. Unfortunatey this is not the case, for mining debris usually will be discharged during the greater part of the year.

Effect of Mining Debris on Fish Foods

Stream bottom samples were taken in the areas studied in order to determine the relative abundance of fish-food organisms in silted and clean bottoms. It should be borne in mind that none of the streams examined showed the effects of recent hydraulic mining, except the North Fork of the Yuba River near its entrance into Bullard's Bar Reservoir. Here, it was plainly apparent that the fine shifting gravel and sand carried by the current along the stream bed offered no stable shelter either for small aquatic organisms or fish.

All the stream bottoms from which samples were taken were of relatively stable structure. The mining debris present took the form of a light to heavy coat of fine silt or mud on the bottom stones.

Relative numbers of bottom organisms per square foot from main stream samples are not significant, since silting was in most cases light and other conditions varied widely. However, when silted and clean tributaries are compared, the production in silted areas is shown to be distinctly inferior to that of the clean. Thus, the production in silted Yuba tributaries is but 63 per cent of that in the clean, while silted American River tributaries produced only 41 per cent as much as the unsilted areas.

A survey of the Klamath River basin (Taft and Shapovalov, 1935), where hydraulic mines were being operated, revealed that "Whenever a series of quantitative bottom samples was taken in one stream or in a series of similar streams during the summer, the average number of food organisms in the one-square-foot samples was *always* less in mined areas than in non-mined areas." A particular instance is reported of samples taken on Scott River above and below the entrance of suspended hydraulic mining debris from Grouse Creek. Three samples from silted areas averaged 36 organisms per square foot, while 3 from the clean bottom above averaged 249 organisms per square foot.

Mining and Other Diversions

A serious problem which will arise with the resumption of hydraulic mining is that of keeping trout out of diversion ditches supplying the mines. This appears to be the principal threat to trout above the debris dam and mining areas. Careful screening of all such diversions should be a minimum requirement for the protection of the license-fee investment made by sportsmen in State hatcheries for the rearing of trout. If it is found desirable to stock the debris reservoirs, the diversion of water from them for irrigation, power, or other uses will likewise constitute a menace to fish life which also must be averted by adequate screening.

Debris Dams and Hydraulic Mining in Relation to General Economic and Recreational Values

Whether or not the debris dams are economically justified from the standpoint of mineral values was scarcely within the province of the survey; yet the challenge which this type of permanent structure represents to self-renewing natural resources can not be ignored.

According to calculations reported by the Hydraulic Mining Commission (1927), the value at that time of gold which could be taken in 20 years from hydraulic mines workable under the Debris Control Project is \$18,972,000 or \$948,600 per year. This is probably far greater than the annual money value to be derived from the fishery associated with even the greatest potential run of salmon in the Yuba and American rivers. Nevertheless, it must be kept in mind that while the production of gold will ultimately end, salmon can go on reproducing their kind indefinitely; and the debris dams will continue indefinitely to restrict present and potential salmon runs and the permanent economic values to be derived therefrom.

In determining the best uses to which the waters of the American and Yuba rivers can be put, a broad view is needed. Such a balanced appraisal is within the sphere of the National Resources Committee formed by President Roosevelt in 1935, which, enumerating in a recent publication[8] the characteristics of a sound Federal policy in this regard, states: "In determining whether or not projects are justifiable, and in distributing the costs of projects among beneficiaries, it will take account of social benefits as well as economic benefits, general benefits as well as special benefits, potential benefits as well as existing benefits, where they are involved."

Concerning recreational values in the areas of renewed hydraulic mining, the survey found little evidence of possible impairment. As has been stated elsewhere in this paper, relatively little sport fishing is done in these areas except early season angling in some lower tributary creeks. Furthermore, the area is not favored for summer residences or camps. People from the valleys and the coast prefer the cooler regions at higher elevations.

It is undoubtedly true that greater recreational use would be made of the lower Yuba and American river basins had it been a part of public policy to keep these basins unimpaired as regards the attractiveness of their hills and waters. Hydraulic and other mining has done considerable damage to the scenic beauty of streams and countryside, which damage will be increased by the reopening of the hydraulic mines.

Future planning of debris dams and similar structures should involve parallel engineering and fisheries investigations. This would permit a balancing of interests and consideration of all values upon which sound decisions should rest.

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[8] "Water Planning," National Resources Committee, Washington, D. C., 1938.

Summary and Conclusions

(1) A biological survey of the American and Yuba rivers was made, in accordance with methods used by the United States Bureau of Fisheries, in order to determine the probable effects of hydraulic mining, and debris-storage dams and reservoirs on fish life.

(2) The physical features of the Yuba and American river basins, with modifications due to mining, are briefly described.

(3) Facts are presented which show that early mining and later impassable dams greatly reduced the salmon runs in the American and Yuba rivers, and that these runs, at least that of the American River, may within late years have been increasing in size.

(4) Data from the fish studies show that the erection of high debris dams will block present and potential runs of salmon and steelhead trout from spawning grounds above them for all time.

(5) Counts of migrating fishes indicate that existing spawning runs of salmon which will be blocked by the dams are of slight commercial value.

(6) Observations show that there is danger of young trout being lost in diversion ditches supplying hydraulic mines, unless such diversions are properly screened, since the water will often be taken from good trout streams and lakes.

(7) The survey revealed that the area which will be affected by the resumption of hydraulic mining and the resulting debris, is at present of slight value for sport fishing or recreation because of present mining activities. Much of the area is, however, otherwise suitable for trout, so renewed hydraulic mining will delay restoration of potential sport fishing.

(8) Observations are described which indicate that muddy water discourages spawning by salmon and, conversely, that clear water is preferred for this activity.

(9) Data are presented on quantitative samples of stream-bottom fish-food organisms taken in clean and silted areas. They show that the clean bottoms produce more fish food than the silted bottoms. This indicates that renewed hydraulic mining will reduce the fish food supply in the stream areas concerned.

(10) Observations at the completed North Fork Debris Dam on the American River indicate that an appreciable amount of silt flows over the crest, which may possibly discourage salmon from spawning below the dam.

(11) It is concluded that renewed hydraulic mining will be only slightly detrimental to sport fishing but, as noted in paragraph 4 above, the debris dams will effectively prevent for all time any possible restoration of salmon or steelhead runs to spawning grounds above their sites. Since observations show a debris reservoir to be incapable of settling out fine mud, the amount of spawning by salmon below the dams may persist at a low level or even decrease, unless runs can be reestablished in the South Fork of the American River and in Dry Creek, a tributary of the Yuba River, both of which contain the relatively unpolluted, clear water preferred by salmon for spawning.

Recommendations

If the salmon runs in the Sacramento River System are to be increased, every available tributary must be utilized to the utmost, and with respect to the Yuba and American rivers the following measures should be taken. These measures are designed to correct conditions existing *before* the construction of the new debris dams, and the cost of carrying them out can not be charged directly against the present Debris Control Project. The various structures which have damaged the runs are owned by, or are under the jurisdiction of, a number of different agencies, and it is beyond the scope of this report to determine the responsibility for correcting the faulty conditions herein described.

(1) Fish screens and a by-pass should be installed at the Folsom Dam power diversion to protect downstream migrating salmon and steelhead trout.

(2) A permanent fish ladder should be installed at the north end of the Daguerre Point Dam on the Yuba River in order that salmon may run into Dry Creek, whose waters are more clear and favorable to spawning than are those of the Yuba River. If this is done, fish screens and a by-pass should be installed at the Hallwood Irrigation District Diversion at the Daguerre Point Dam to protect the downstream migrants.

(3) The South Fork of the American River should be made more accessible to salmon by the construction of fish ladders over the two salmon falls, and by the repair of the fishway at the American River Head Dam of the Pacific Gas and Electric Company.

(4) All diversions for mining which take water from streams or lakes known to provide sport angling, and diversions from debris reservoirs, should be screened.

(5) Cyanide pollution and heavy silting from stamp mills and other sources have for many years damaged some streams. This condition must be corrected if such streams are again to be made habitable for salmon or trout.

List of Fishes Known or Presumed to Occur in the American and/or Yuba River Basins

Species with an asterisk (*) after the first number were collected or observed.

Native Species

1.*	(16, 17)[9]	*Entosphenus tridentatus* (Gairdner). Three-toothed lamprey.
2.*	(331)	*Oncorhynchus tshawytscha* (Walbaum). King salmon, chinook salmon.
3.*	(357)	*Salmo gairdnerii* Richardson. Rainbow trout, steelhead trout.
4.*	(738)	*Catostomus occidentalis* Ayres. Sacramento sucker.
5.*	(798)	*Mylopharodon conocephalus* (Baird & Girard). Hardhead.
6.	(804)	*Lavinia exilicauda* Baird & Girard. Hitch, Chigh.
7.*	(807)	*Ptychocheilus grandis* (Ayres). Sacramento pike, whitefish.
8.	(829)	*Pogonichthys macrolepidotus* (Ayres). Split-tail.
9.	(855)	*Siboma crassicauda* (Baird & Girard). Sacramento chub.
10.*	(863–8)	*Hesperoleucus* sp. Roach.
11.*	(871–7)	*Siphateles* sp. Lake chub. Possibly brought by anglers as bait from Tahoe region.)
12.*	(1052–8)	*Apocope* sp. Black minnow.
13.	(1852)	*Gasterosteus aculeatus* Linnaeus. Stickleback.
14.	(2345)	*Archoplites interruptus* (Girard). Sacramento perch.
15.*	(2996–3003)	*Cottus* sp. Riffle sculpin.
16.	(3252)	*Hysterocarpus traski* Gibbons. Fresh-water viviparous perch.

Introduced Species

1.*	(213)	*Alosa sapidissima* (Wilson). Shad.
2.*	(___)	*Salmo trutta* Linnaeus. Loch Leven trout, brown trout.
3.*	(371)	*Salvelinus fontinalis* (Mitchill). Eastern brook trout.
4.	(___)	*Cyprinus carpio* Linnaeus. Carp.
5.*	(1164)	*Ameiurus nebulosus* (Le Sueur). Square-tail catfish.
6.*	(____)	*Gambusia affinis affinis*. Mosquito fish.
7.*	(2314)	*Huro salmoides* (Lacépède). Large-mouthed black bass.
8.*	(2315)	*Micropterus dolomieu* Lacépède. Small-mouthed black bass.
9.*	(2317)	*Lepomis cyanellus* Rafinesque. Green sunfish.
10.*	(2332)	*Lepomis macrochirus* Rafinesque. Bluegill sunfish.
11.	(2351)	*Pomoxis annularis* Rafinesque. White crappie, crappie.
12.	(2352)	*Pomoxis sparoides* (Lacépède). Black crappie, calico bass.
13.	(2366)	*Roccus lineatus*. Striped bass.

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THE CALIFORNIA SHARK FISHERY[1]

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In one year the California shark fishery skyrocketed from a minor to a major position in the fisheries of the State. This leap to prominence is due entirely to the present demand for vitamins and the discovery that shark livers are rich in vitamin A. Prior to 1937, sharks were caught incidentally to other fishing. In central California they were considered almost worthless and few were brought ashore, although a small proportion was filleted, and the fins of the soupfin shark were dried and sold for soup stock. The market for sharks was better in southern California and the fishermen could usually sell those they caught. As a result of the demand for liver oil, more pounds of sharks were landed in 1938 than either salmon, albacore or rockfish. The accompanying figure 11 shows the sudden impetus the fishery received and also the proportional amount of the catch taken in central and southern California. This rapid rise in demand for shark liver oil has focused the attention of the fishing industry, as well as the public, upon the maligned shark as a profitable field for exploitation. To find the answers to the numerous questions that constantly pour into the Laboratory and other offices of the Division of Fish and Game, concerning this new fishery, was the reason for this study. The aim in view was to obtain a comprehensive picture of the fishery. This included the methods of catching the raw product and methods for its utilization following its capture.

HISTORY[2]

Sharks destined for liver oil production were first delivered to Al H. Meyer on January 28, 1937. Prior to that date, the soupfin sharks delivered incidentally to other fishing had their fins removed, along with some of the choicer cuts of steak that were later sold to the consumer as grayfish, fillet of sole or swordfish. The rest of the carcass was run through a reduction plant. Sharks other than soupfin were seldom brought ashore as there was little demand for them. Before 1937 some fish processing companies had experimented with shark liver oil but it was not until January of that year that the industry started on a commercial basis.

Sharks valuable for their liver oil were sold to the California Packing Corporation's plant at Monterey, where special equipment for handling these livers and carcasses was installed. The F. E. Booth Company entered the field about the same time in San Francisco.

[1] Submitted for publication, November, 1939. The author is indebted to the many members of the industry who helped in the preparation of this paper. Photographs by author.

[2] The author is indebted to Al H. Meyer for the information on the historical background of the shark fishery.

In 1937 three market jig boats, fishing set lines and working out of Monterey, were the nucleus of the present shark fleet that numbers about 600 boats scattered throughout the State; although this number is never fishing sharks all at one time. The demand for sharks interested the white sea-bass fishermen of Santa Cruz who often took sharks in their nets and threw them away because no buyers wanted them. In 1937 they built special nets with the intention of fishing sharks consistently. As landings on more profitable fish decreased—or as seasons closed in other fisheries—more and more boats turned to shark fishing

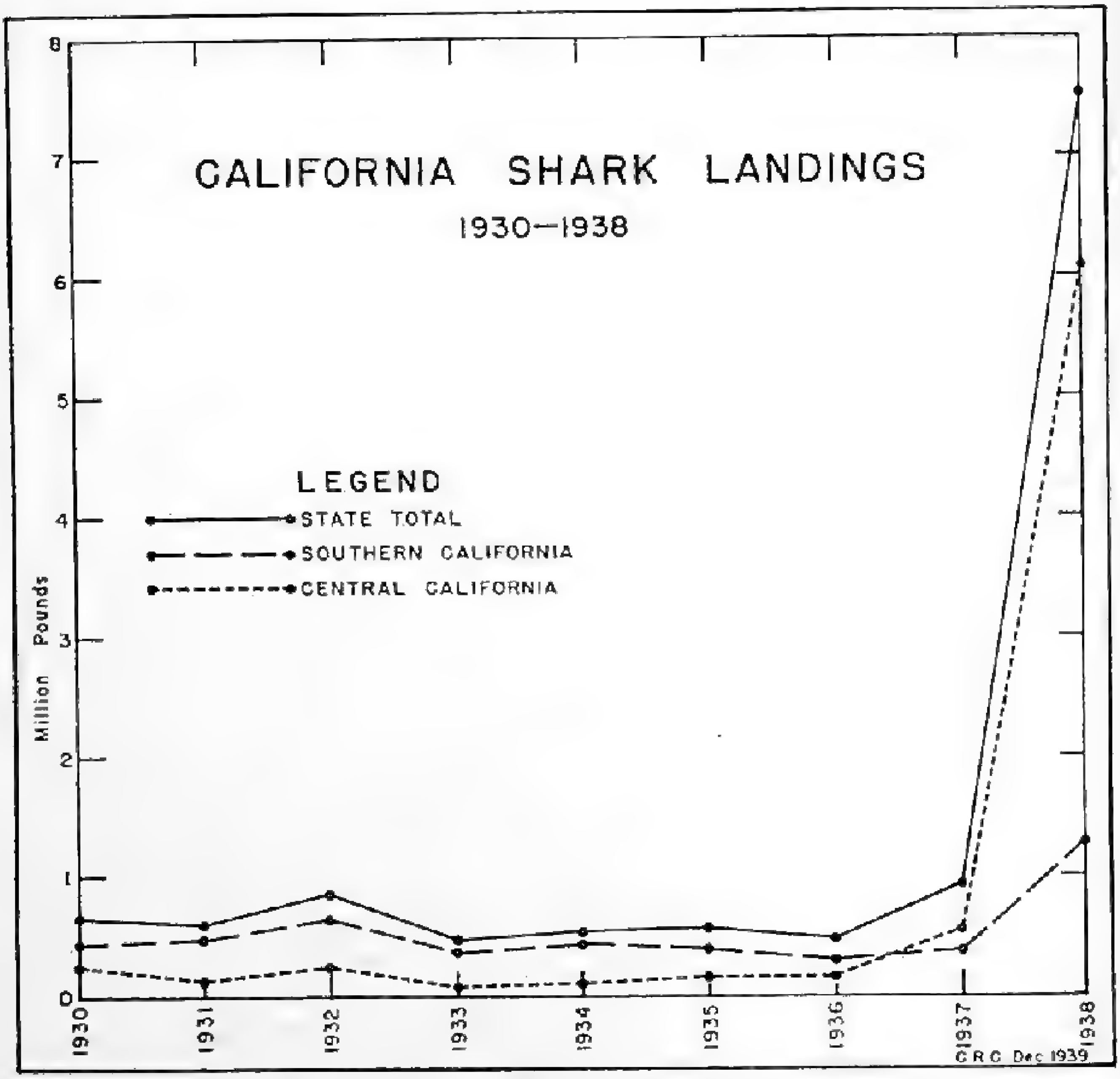

FIG. 11. Landings of sharks in central and southern California, 1930-1938.

as an off-season industry. This is true to a certain extent at the present time, as when albacore or salmon are running very few boats fish for sharks, returning to them only after the run is over. Soon after operations started at Monterey, San Francisco boats tried out experiments to adapt their set lines to the more rugged type of gear that constant shark fishing requires. In January, 1939, several halibut boats from the Northwest visited the port of Monterey to investigate this new fishery and try out their northern halibut gear on the soupfin shark. Sev-

eral months were spent by these boats in scouting the coast of California to determine the most favorable locality, type of bottom, and depth at which the sharks are most abundant. The skippers of these boats are planning to return to Monterey at the close of the next halibut season to investigate shark fishing more fully. Expansion of fishing area has spread southward toward the warm waters of Mexico and the Gulf of California, where Ensenada and Guaymas are the key ports. At the present time, these southern ports are taking sharks more on an experimental basis than a commercial one, as analysis has shown the vitamin potency of these warm-water sharks is greatly under that of the northern ones even for the same species. However, some of the methods developed at these tropical ports are being introduced into the California fishery this winter. Plans are going forward for the industry to equip a small purse seine boat with gear suitable for shark fishing. This boat will spend its time scouting the California coast and trying out different methods of fishing, at the same time gathering information on the habits and movements of sharks. It will also act as a pick-up boat for the smaller market fishing boats. Fishing sharks all year around instead of intermittently will give a clearer idea of the abundance or scarcity of sharks at any given season for that locality.

FIG. 12. Market fishing boats. These boats fish for sharks with gill nets and lines. The operator controls the boat and handles the gear from the small cockpit in the stern.

BOATS AND GEAR

In the history of shark fishing, there have been several large boats built and equipped with expensive machinery to take sharks on a large scale. As a rule these boats intended operating in tropical waters where sharks are more abundant. Usually such ventures were a dismal financial failure because of the indebtedness contracted without an adequate return on the investment. The most successful boats at present seem to be those small ones which are already engaged in some type of

fishing, and can with a minimum of expense be equipped to catch sharks. Those such as the Monterey type of market fishing boats are admirably adapted for this purpose as they are small, economical to run, and versatile enough to be used for a variety of fishing conditions.

In a fishery as new as this one the changes in gear and methods are unpredictable, and the evolutionary process will be gradual and subject to considerable trial and error before the most efficient combination is developed. At present this development is proceeding along two separate lines. The first fishing done at Monterey was with set lines, although the second method—gill netting—followed soon after at Santa Cruz. Both of these types of gear are handled from the Monterey market boat. These boats are from 20 to 35 feet long with a clipper bow and short bowsprit. They have wide flaring sides, either a fan-tail or compromise stern, and are designed with a small deckhouse which shields the helmsman from the weather. Some have an additional small cockpit near the stern, from which the gear can be handled, as well as the controls for the engine and the tiller. A hatch on the afterdeck provides handy access to the hold. Sideboards about 18 to 24 inches high allow for an additional deck load. The larger of these boats have a mast and boom, while the smaller ones substitute for the mast a pair of stout wood or bamboo poles, which are used in trolling for salmon and albacore.

Gill Nets Used in Monterey Bay

Two types of gill nets are used, namely drift gill nets and set gill nets. The choice depends on the season, condition of the bottom, weather and the depth at which the sharks are found. The drift gill nets are made of 21- or 24-thread cotton line, medium laid, with a stretched mesh of 8 inches. The net is 45 or 46 meshes deep and 45 or 46 fathoms long. A ¼-inch diameter cork line, designated as No. 6 thread, is fastened to the upper end of the net by a hanging of 24-thread cotton line, soft laid. This cork line is laced through 4-inch corks with three meshes between each adjoining cork, and the corks are put on singly. The lead line is also 6-thread line, and is laced to the webbing with 24-thread line, soft laid, which gathers together 3 meshes and fastens them to the lead line at one place. The leads, which weigh 2 ounces, are attached to the lead line between the successive groups of gathered meshes. When drifting on the surface, only a few leads or none at all are used. For drifting at various depths under the surface, leads are added until the weights and corks balance at the desired depth. This type of net is fished at night, the method being to attach one end of the net to a buoy and the other end to the boat, allowing both to drift till morning; the net is then hauled in, and the sharks, if any, are removed.

The set gill nets are approximately half the size of the drift gill nets, being only 26 meshes deep and 25 fathoms long. The mesh and thread size are the same as the drift gill nets. The corks are attached in the same way, and the leads laced on a No. 9 thread line. This 9-thread line is 5/16-inch in diameter and is larger than the lead line of the drift gill nets because of the extra wear it gets on the bottom.

A 25- to 35-pound anchor is fastened to each end of the net, and buoy lines lead from the anchor and cork line to the surface, where they are attached to markers. These buoy lines are several fathoms longer than the depth of the water. The depth these nets are fished varies with the sharks, but they are seldom fished deeper than 25 fathoms. They can of course be used only on a smooth bottom. Two men can handle six nets from one boat. The northern portion of Monterey Bay around Capitola comprises the fishing grounds for the gill net boats.

Set Lines or Trawl Lines

In Monterey Bay the rock cod fishermen are trying out set lines on sharks, as they are quite familiar with handling this type of gear. The set line is made of $\frac{1}{4}$-inch diameter, 6-thread, 3-strand, hard laid, tarred or untarred manila buoy line. Attached to this, at intervals of 12 to 13 feet, are the gangings or leaders, carrying the hooks. These gangings are made of 72-thread, hard laid, white cotton line. They are cut a little longer than three feet and one end is fastened to the set line with a clove hitch. The short end is tied with an overhand knot to keep it from pulling back through. The hook end of the ganging is doubled back for about 6 inches and tied with an overhand knot, leaving a loop which is threaded through the eye of the hook and pulled up taut around the shank. An 11/0 hook is used. These lines vary in length, but about 70 hooks to a line is the average. The lines are held on the bottom by a large rock or an anchor, and attached to this is a buoy line of $\frac{1}{4}$-inch rope leading to a wooden keg and flag marker on the surface. Sardines and mackerel are the preferred bait, but anchovies and herring are used when other bait is not available. The fishing grounds have not been standardized as yet, although most Monterey boats limit their activities to that section of the coast between Port San Luis and Half Moon Bay.

In the San Francisco area, two sizes of lines are used. When fishing for small sharks, the fishermen use rock cod gear consisting of 216-thread cotton line, with 33-thread, hard laid, gangings 3 feet long and 3 feet apart. At first a 6/0 hook was used but this proved to be too light for the tough jaws of a shark and now 9/0 hooks are being used. Each line carries about 200 hooks and this unit is kept by itself in a basket or small box with the hooks stuck around the edge. Two men working from one boat can handle eight of these baskets. This type of gear is a compromise with rock cod gear. It is a more generalized gear and is adapted to more than one type of fishing, the catch depending upon the locality and the season in which it is set.

When fishing for large sharks a more specialized type of gear is preferred. The same set line of 216-thread is used, but the hooks are spaced 12 feet apart and only 70 are used to a line. The gangings are made of 72-thread, hard laid, cotton line, 3 feet long. Originally, 12 inches of 1/16-inch diameter chain was attached between the cotton line and the hook, but this proved unnecessary. Now only 72-thread line is being used with 11/0 to 14/0 hooks. The lines are anchored and buoyed the same as the smaller lines. Two men and a boat are able to fish 10 of these lines. The rules of a special permit require that only hard-salted sardines be used as bait when fishing in San Francisco Bay.

The bay provides excellent shark fishing in certain seasons and several million pounds were taken from this area in 1938. During good weather the boats also fish outside San Francisco Bay in the vicinity of the Farallon Islands and along the coast to Half Moon Bay. Set lines are fished between 10 and 100 fathoms.

The fishing gear used at Half Moon Bay is the same as that used at San Francisco—set lines. Since both Monterey and San Francisco boats fish at times in Half Moon Bay with set lines the methods previously discussed apply also to this port.

In Santa Barbara the fishery centers around the Channel Islands. Each set line carries 50 hooks, sizes 12/0 to 15/0, and these are spaced 6 fathoms apart with 3-foot leaders. About 6 lines to the boat is the

FIG. 13. Halibut boat. Note the chute on the stern and buoys amidships. The power gurdy is visible near the starboard rail aft the fore mast.

average. Mackerel is the preferred bait as the tough skin keeps it on the hook better than sardines, and the oiliness is considered an added attraction to the shark. At first, the boats fished at 40 fathoms but it was discovered that by fishing at 100 fathoms the season was able to open one month earlier. It is thought that the sharks are found in deep water prior to the inshore spawning migration. The sharks are usually shipped to Monterey in the round for subsequent processing.

San Pedro and San Diego have not expanded greatly since the shark fishery went on a liver oil basis. Fishermen there have always caught sharks for a well-developed food market. Now the livers are shipped to processors but the fishery is still on a food basis. The sharks are still caught incidentally to other fish and only a few boats fish sharks exclusively during the summer months.

Seattle Halibut Gear Used in California

In the early months of 1939 six Seattle halibut boats, working out of Monterey and San Francisco, fished for sharks. These halibut boats are characterized by straight stems, high freeboard and gaff-rigged masts. They may carry one or two of these masts, and the small area of sail used is intended to act as a stabilizer and does not furnish much

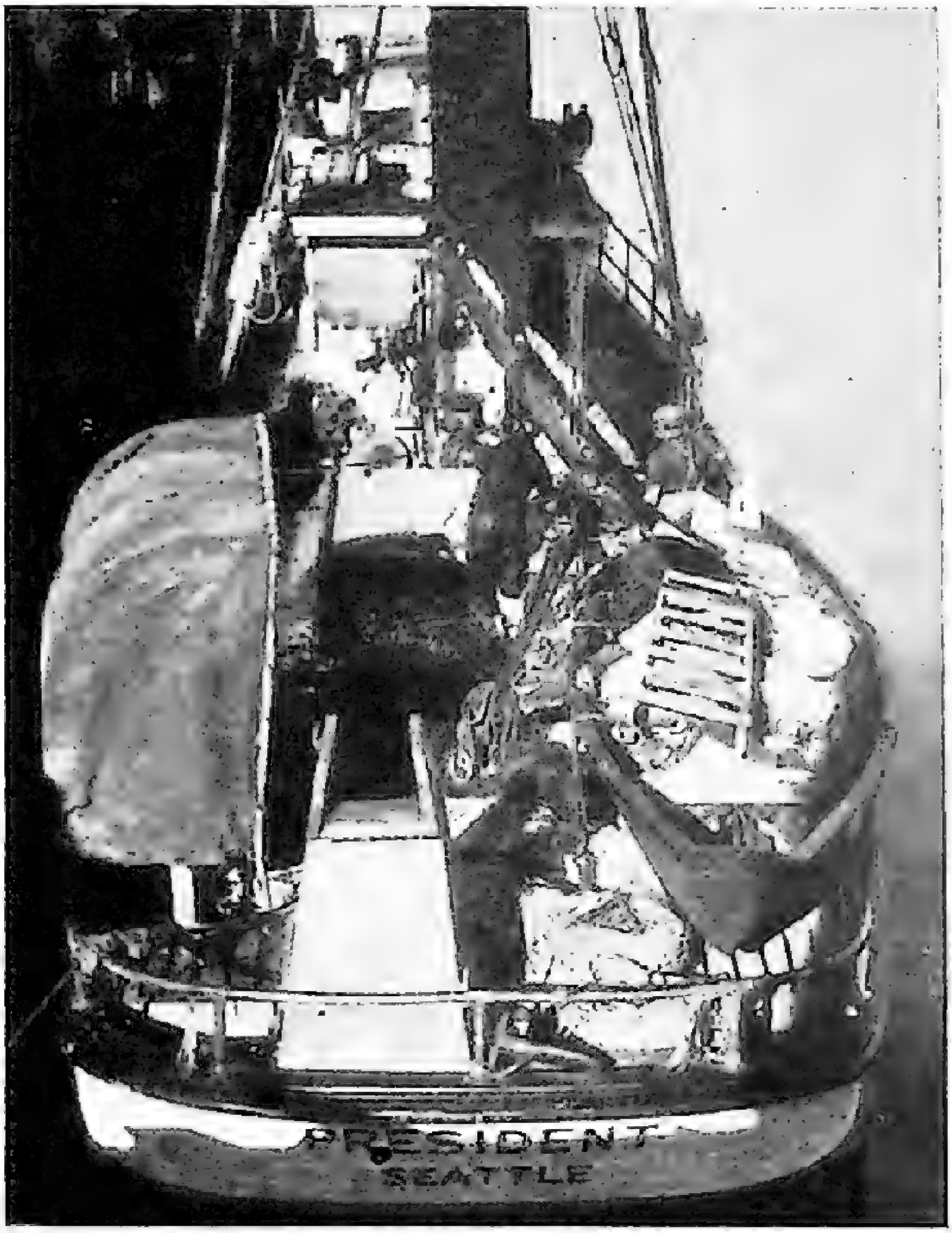

FIG. 14. Another view of a halibut boat showing the canvas over the bait tables on the port side and the set lines coiled on the stern. The power gurdy can be seen just aft of the mast.

driving power. The boats range between 40 and 60 feet long, on the average, are powered with diesel motors of 60 to 75 horsepower, and have hold capacities between 25 and 30 tons. The crew quarters and galley are in the forecastle; immediately aft of this is the engine amidships, and following this aft is the hold which runs almost to the stern. The pilot house on deck is equipped with a bunk for the master. Just aft of the pilot house, in the center of the deck, is a raised coaming about six feet square. A hatch cover fits over this coaming, and an

additional manhole in the large hatch cover provides access to the hold without removing the large cover. Between this hatch and the deckhouse is the power gurdy that hauls the lines. The line comes in over a roller on the gunwale, runs to the power gurdy, makes a complete revolution around it, and is coiled down by hand as it leaves the gurdy. Small sharks are pulled over the gunwale by the gurdy, but large ones are raised by a hand gaff. On the stern is a high, rounded, metal-lined chute, resembling at a distance the ornate bow of early Viking boats. This chute prevents the lines catching on the gunwale as they run out over the stern. On the port quarter is a bait cutting table. A canvas tarpaulin fastened to a framework of pipes protects the bait cutters. On the starboard quarter are the dories, usually one or two nesting inside each other, filled with odds and ends of gear, anchors, rope, buoy floats and fishing lines. These dories are not used in shark fishing, as the lines are set directly from the boat.

The gear used by these boats has been the regular halibut gear. The long set line is divided into units called skates. Each skate is 300 fathoms long and is made of 6-thread, ¼-inch diameter, hard laid, tarred, 3-strand, buoy line. Attached to this line at 13-foot intervals are loops of lighter, 4-strand, hard laid line known as "beckets." Through these beckets the 2-foot ganging or leader is fastened. The regulation halibut ground line is designated by pounds, such as 28-pound or 48-pound per skate. This method is not used in California and when the halibut men built extra skates they used the ¼-inch line described above. This rope is cheaper, and for sharks is just as satisfactory as the more expensive halibut line. Each skate is baited and handled by one man. The 10/0 hooks are baited and placed on the inside of the coil. There are two or three complete revolutions of the ground line between each successive ganging bringing all the gangings on one side of the coil when the line is baited. The baited coils are laid in a group near the chute and a 25-pound anchor is attached to one end of a skate. A buoy is attached to the anchor with a line about 25 fathoms longer than the depth of the water. Fastened to the buoy is a bamboo pole approximately 10 to 15 feet long, weighted at the lower end with sash weights. Four feet from the lower end of the pole, cork floats are fastened by pushing the pole through the holes in their centers. From 9 to 14 of these corks are used depending upon their condition and flotation ability. Secured to the upper end of the pole is a red flag, and some poles are equipped with a small electric bulb fastened at the very tip. This bulb is wired to a dry cell kept in a waterproof brass container with a screw top. The battery has a life of about 70 hours and is used for night fishing.

In operation the buoy and marker are first thrown overboard, followed by the anchor. The skates are payed out over the chute while the boat is traveling ahead at cruising speed. As soon as one skate is started over the chute, the other end is tied to the following skate, each one helping to pull out the next. After 4 to 14 skates have been run out, an anchor and buoy are fastened to the last skate which completes a unit of gear. (See Fig. 15.) This series is called a string. Several strings may be set out and their length depends upon the weather conditions and the bottom. For sharks the strings are set in depths between 10 and 250 fathoms.

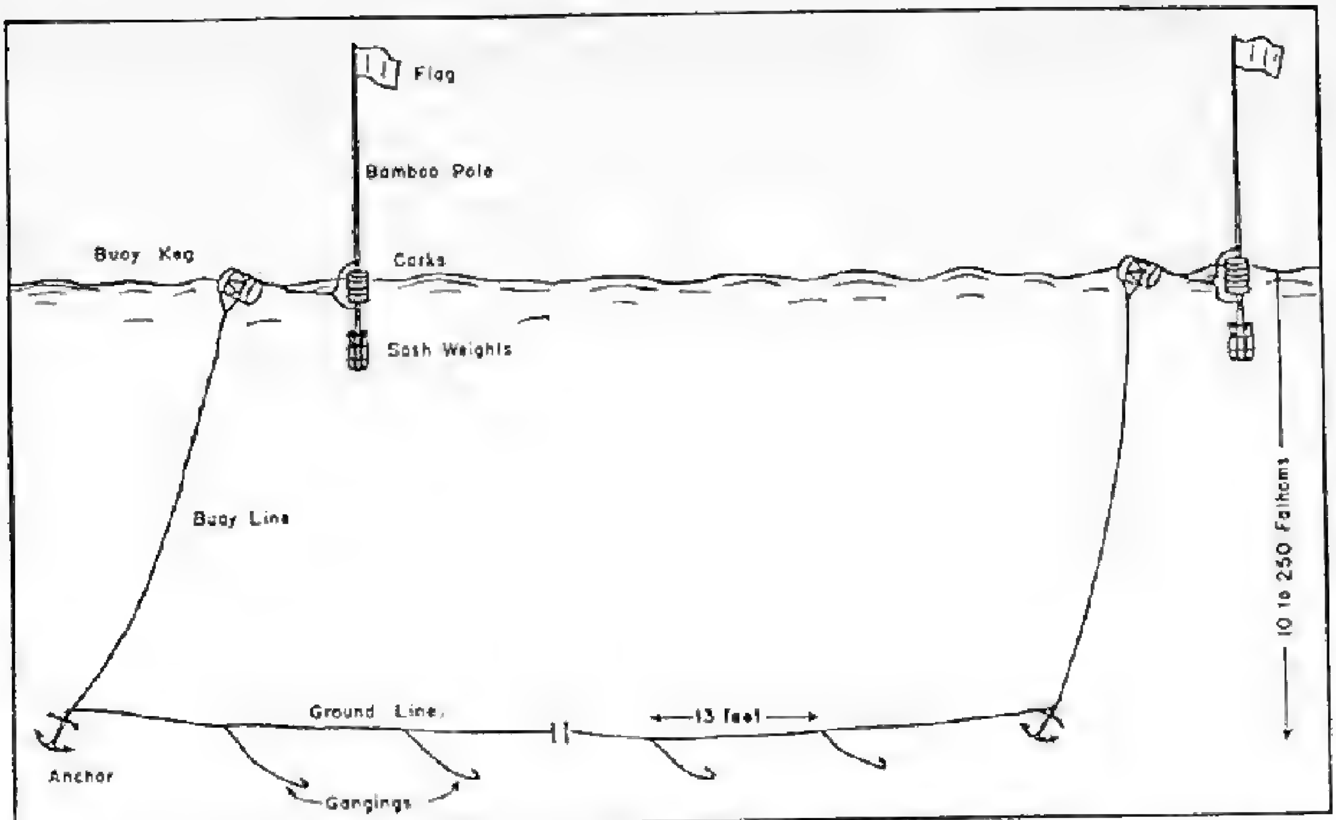

FIG. 15. Diagram showing halibut gear as used in shark fishing, not drawn to scale. Each string of gear consists of 4 to 14 skates; each skate is about 300 fathoms long. (Adapted from figure 5 of International Fisheries Commission Report no. 1.)

REDUCTION OF CARCASS[3]

At the shark market where the fisherman delivers his catch, all varieties of sharks are present, piled on the floor, waiting to have the livers removed. They are carried to a long table where the abdominal cavity is opened with one stroke of a knife, and the liver pulled out. The liver is dropped, with other livers of the same species of shark, into a five-gallon liver can. Livers of different species are always kept separate. These cans are kept in cold storage pending the processing of the livers. In the case of the soupfin shark, the dorsal fins and the lower lobe of the tail fin are removed—as these bring a good price from the Orientals for soup stock. In San Pedro and to a lesser extent in central and northern California a certain percentage of the choicer varieties are filleted for food. The liver oil extraction is done in a specially equipped plant, and the carcasses may be either run through a separate reduction plant, or be disposed of to other plants for reduction. The type of machinery used in liver and carcass reduction is entirely different. Some plants specialize in livers while others take only carcasses.

The carcass is run through a reduction process that converts it to fish meal. The first step in reduction is putting the carcass crosswise through 10 circular saws set 4 inches apart. These are fastened to an axle holding them together as one unit. The separate chunks of shark are then passed through a hogger that breaks up the tough hide and makes it easier to process. This hogger, or coarse grinder, is a heavy flywheel with 3 equally spaced teeth projecting from the rim. These

[3] It is suggested that the reader compare meal and oil processes with those in the sardine industry. See "Reduction processes for sardines in California," by S. R. Hatton and G. R. Smalley; California fish and game, vol. 24, no. 4, pp. 391-414, 1938.

teeth pass between other teeth fastened on the frame, grinding the chunks of meat as they fall between the stationary and the rotary teeth. Bucket elevators then carry this ground meat to the cookers, after which it is pressed to remove some of the moisture. The meal goes from the press to a rotary dryer, and the stick water into a Footes separator. From the dryer it passes through a vertical disintegrator which grinds it to the desired fineness and is then sacked. A plant capacity is about 6 or 7 tons of sharks per hour. This process gives a meal of 80 per cent protein content, which is in demand throughout the Middle West as a stock food, selling for the same price as sardine meal. The amount of oil yielded by the carcass is negligible and not worth the expense of recovering it.

EXTRACTION OF SHARK LIVER OIL

Methods used for the extraction of liver oil vary from heating the minced livers in open tubs and skimming the oil off the surface, to highly refined technique where each step of the process is under laboratory control. The more specialized steps are secrets of the company developing them, but the basic methods are coagulation and pressing, or oil solvent extraction. High speed centrifuges are gradually superseding the older methods. The newest entry in this field is a three-phase separator with a high sludge capacity, the solids accumulating in a bowl which is dumped while the machine is in motion. A quick-freeze plant is operated in connection with the liver oil plant. The livers are kept frozen until the time of processing them.

Centrifugal Method

The frozen livers are placed in a warm room and allowed to thaw out. This thawing room is equipped with a fine grinder through which the thawed livers are run. Next, the ground livers are conveyed to either a double-jacketed steam cooker or a direct steam cooker, and cooked long enough to stop the enzyme action. This cooked material is then passed through a three-phase centrifuge and the free oil obtained is stored. The sludge is either discarded, or further treated with an oil solvent extraction process, depending upon the percentage of recovery obtained and the amount of residual oil present. A 90 per cent yield of the oil present can be obtained with this method, but it is not all high potency oil. Using this method, a plant capacity is about 200 pounds of liver per hour.

Coagulation and Pressing

The descriptions of this and the two following methods were largely taken from an article by Brocklesby and Green.[4] The treatment in California varies between plants as standardization has not been achieved. Ordinary steaming and pressing methods, as are used on whole sardines, are unsatisfactory when tried on shark livers due to their soft, pulpy consistency. As a pressure of 5000 pounds per

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[4] Brocklesby, H. N., and Green, K.
1934. Methods for the production of oils from fish livers of low oil content. Pacific biological station, Nanaimo, B. C., and Pacific fisheries experimental station, Prince Rupert, B. C. Progress reports, no. 22, pp. 8-10.

square inch is necessary to get the oil, it was essential that some method of treating the livers to withstand this pressure be developed. It was found that pressure cooking at 10 to 20 pounds pressure for a period between a half and two hours permitted a pressure of 8000 to 9000 pounds per square inch before the undesirable protein matter was squeezed through the press cloth. A 60 per cent oil yield was obtained with this method. However, with the 20-pound cooking pressure, the oil obtained had a dark color and tests showed a certain amount of hydrolysis had taken place, with an increase in the free fatty acid content—besides a loss of some of its vitamin A potency. Experiments using a cooking pressure of 10 pounds for one-half hour and adding 10 per cent of sodium chloride or ammonium sulphate gave a hydraulic pressure of 9000 pounds and a 50 per cent oil yield of good color with no loss in vitamin content. The press cake had to be treated with a solvent extraction process to recover the remaining oil.

Oil Solvent Extraction Process

This method used with variations by operators in California is based on the fact that all naturally occurring fats and oils are soluble, as well as the vitamins A and D occurring in such oils. The minced livers are covered with an oil to be used as the solvent. As a certain amount of this solvent oil is retained in the product, it should be palatable and of a good quality. Sardine oil, grayfish liver oil and olive oil are some that have been used. The mixture of solvent and raw liver is heated to 212° F. for a period which varies with the ratio of oil to liver, but is seldom less than half an hour, during which time it is stirred. The livers absorb some of the solvent oil during this time, while the liver oil becomes distributed throughout the entire mixture. The free oil is then obtained by settling or by a high sludge capacity centrifuge. The remaining liver material is again treated with a further quantity of fresh solvent oil until all the vitamins have been dissolved out. The extracted oil may be used immediately or employed to extract vitamins from fresh batches of livers. By successive extractions, the potency of the solvent may be increased many times over.

Digestion, Peptization and Centrifuging

This method is not in use in California but has given good results on a semi-commercial scale elsewhere. The livers are minced and diluted with an equal volume of water, and enough 25 per cent hydrochloric acid is added to reduce the pH to between 1.2 and 1.5. This low pH is maintained during the digestion process and is to prevent bacterial action, as well as to retard the activity of fat-splitting enzymes present in the livers. Commercial pepsin, 0.05 per cent by weight of the fresh livers is added, dissolved in a little water. The mixture is maintained at a temperature of 110° to 120° F. for a 36- to 48-hour period, during which time it is slowly stirred. At the end of this time a quantity of saturated sodium carbonate solution is added (the amount determined by a test sample of each batch), the mixture is heated to about 175° F. for a few minutes and then passed through a centrifuge.

A 90 to 95 per cent yield is obtained. This oil is a clear, lemon-yellow color and has a vitamin potency equal to samples treated with the laboratory solvent extraction method.

Vitamin Potency of Different Species

The number of units of vitamin A per gram for the different species fluctuates considerably and the potency of one oil may be entirely different from the potency of the same liver oil in a different region. Seasonal and individual variations also influence these results; therefore, the great range in the following species, given in U. S. P. vitamin A units per gram: soupfin, 40,000-150,000; dogfish, 2000-20,000; blue shark, 2000-10,000. The ratio of liver to body weight also varies greatly, and while 8 to 12 per cent is considered a rough average, individuals have been reported with the livers weighing as high as 30 per cent of the body weight. The oil content of the livers is between 30 and 70 per cent. Vitamin D is negligible in shark livers, and as sardines provide a good source of this vitamin, no attempt is made to extract it from the shark livers.

PRICE OF SHARKS, LIVER AND OIL

Fishermen receive between $40 and $60 a ton for soupfin in the round and $8 to $10 a ton for all other varieties. Sharks other than soupfin are not in demand, and are taken by the fresh fish markets chiefly as an accomodation to the fishermen.

The proportional amount of each species delivered is difficult to state accurately as often they are classified simply as "shark" without trying to enumerate the different species making up the catch. As a rough estimate between 75 and 80 per cent of the sharks taken are soupfin. The remaining 20 per cent is fairly evenly divided between the grayfish, seven-gill, leopard, and great blue sharks. The soupfin is by far the most valuable from any standpoint. The shark carcasses are usually run through reduction plants indiscriminately of species and no information on protein content of different species is available. The vitamin potency is given elsewhere. The species listed in the order of value are as follows: soupfin (*Galeorhinus zyopterus*), grayfish (*Squalus suckleyi*), seven-gill shark (*Notorynchus maculatus*), leopard shark (*Triakis semifasciata*), and great blue shark (*Prionace glauca*).

Processors pay about 35 cents a pound to dealers for soupfin livers. The current market price is slightly above this but 35 cents is a good average figure.

Vitamin A oil is sold on a million-unit basis, regardless of what weight or volume it is. Oils yielding 100,000 or more U. S. P. vitamin A units per gram, sell between 4 and 8 cents per million U. S. P. units, and are known as high potency oils. Oils yielding 20,000 or less, U. S. P. vitamin A units per gram sell for less than 4 cents per million U. S. P. units, and are low potency oils. Shark liver oil is used entirely as a food fortifier in the animal and poultry industries.

Shark skins have been manufactured into leather for several years by the Ocean Leather Corporation, Newark, New Jersey. A special patented process is used to remove the rough shagreen. At present

there is not a leather processor on the Pacific Coast. Dealers here who have tried removing the shark skin claim the cost of labor involved is greater than the price paid for the skins. Some quick method of skinning will have to be developed before the skins become a profitable side line of the oil business. The east coast sharks are larger and the species used for leather manufacture are not present on the Pacific Coast. Nevertheless some California sharks should be valuable for leather if proper methods are developed for handling the product. Persons interested should communicate with the Ocean Leather Corporation, Newark, New Jersey.

ANALYSIS OF CATCH

The years 1930-1936 were chosen as being the most representative of normal conditions throughout the shark population. While roughly nine times as many pounds of sharks were landed last year (1938) as in the best year prior to 1937, it was felt that due to the tremendous increase in effort these two years would tend to give a wrong impression of actual conditions. A comparison of the 1937-1938 seasons shows many discrepancies with the earlier years, but these differences may be due to many uncertain conditions, such as water temperatures, available food, abundance of sharks or increase in effort. Several years will have to elapse under the present fishing intensity before definite conclusions can be drawn which may be of value in revising present inferences regarding seasonal abundance in the various fishing areas. Therefore in analyzing monthly landings, this account will deal only with the years from 1930 to 1936, and attempt to show a general trend through this period.

An analysis of the monthly landings covering the period 1930-1936 indicates that there are definite seasons when sharks are available to the fishermen. In each region, sharks are more abundant during certain months than at any other time. This seasonal variation in abundance may be due to the fact that sharks have been taken incidentally and their landings fluctuated directly therefore with the variations in the landings of the more important fish. Or, the type of gear used may have varied throughout the year and some kinds of gear may be more successful than others for the taking of shark. A detailed study made of the boat catches for the years 1930-1938 indicates, however, that the monthly variations in the landings of sharks in each region depended on the availability of the sharks and not to incidental factors.

All boats that fished consistently throughout this period were segregated and a monthly catch record made for each boat, giving the kinds and amount of fish taken, as well as the type of gear that was used. San Francisco was chosen as a representative port of northern California, because of the variety of its gear and volume of its fishery. Since most of the sharks were delivered by trawlers, these boats were chosen for detailed study. Most of the trawlers were fishing in the vicinity of Eureka during the summer months, making it difficult to get a year around record of the San Francisco area for any given boat. However, during the years under consideration several boats overlapped their fishing grounds into central California for long enough

periods during the summer to give a trend of the sharks' abundance. The results showed that trawling gear was quite effective for taking sharks, that the amount of sharks taken varied independently from the other species of fish taken by trawlers, and that sharks were more commonly taken during the winter than the summer months. Summer landings on the average were small and scattered in comparison with the winter catches.

In southern California, Los Angeles was selected as being the most representative port. Five boats that fished from 1930 to 1938 were selected for detailed study. One fished for halibut with trammel nets and for barracuda with gill nets. Three were jig boats using hand lines and set lines. The fifth fished white sea-bass with gill nets. A comparison of the catches of these boats indicated that sharks are taken quite consistently with halibut in trammel nets, to a less extent with lines and white sea-bass gill nets. They are also taken incidentally with barracuda and mackerel on hand lines. They are seldom taken to any great extent when fishing sablefish and sculpin. The hand and set line boats at times took more sharks during the summer than any other kind of fish. In the Los Angeles area, sharks were more abundant during the summer months and at moderate depths down to 25 fathoms. A further comparison of the catches indicated shark landings did not fluctuate directly with the landings of the other fish with which they are often caught.

A listing of the best months in each region when sharks were most bundantly taken reads as follows: San Francisco area—November, December, January, February and March; Santa Barbara area—February, March, April and May; Los Angeles area—April, May and June; and at San Diego—June, July and August were the highest months. These months are based on seven-year averages from 1930-1936 and do not necessarily mean that a person fishing the San Diego area in August would take more sharks than he would in some other region, say Los Angeles, but rather that in fishing one region all year the best landings will probably be in the months given. Yearly fluctuations in food, water temperatures and other factors would tend to change the season to a certain extent. Since the expansion of the fishery in 1937, it is difficult to draw definite conclusions, as the great increase in effort has brought thousands of pounds of sharks into the market at a time when in former years scarcely any were being taken.

A comparison of central and southern California as to volume of landings shows that during the period 1930-1936, 27 per cent of all the sharks taken were caught in the San Francisco-Monterey area, while 73 per cent were caught in southern California, between Point Conception and San Diego. The average annual catch during the years 1930-1936 in southern California was 428,044 pounds. Santa Barbara contributed to this amount about 17,500 pounds annually. Los Angeles and San Diego therefore were the principal shark ports in southern California before expansion took place. The landings in this same area in 1938 were 1,279,303 pounds, of which Santa Barbara accounted for 1,014,564 pounds. Santa Barbara alone now averages more than the whole southern portion of the State before 1937. A glance at table 1 shows that San Diego has been little influenced by the increase in shark fishing. Average landings in central California through 1930-1936

TABLE 1

Annual Regional Landings of Sharks, Pounds

	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
Regions 10 and 20, Del Norte and Eureka	2,345	----------	----------	----------	45	----------	----------	1,687	140,440	38,359
Regions 30 and 40, San Francisco Bay and ocean	221,672	121,802	223,694	93,971	106,366	159,770	170,451	407,637	4,318,598	4,563,188
Region 50, Monterey	8,925	1,147	5,943	2,315	400	350	3,105	122,253	1,765,845	1,824,354
Region 60, Santa Barbara	11,018	505	13,793	22,303	25,088	37,625	22,211	123,477	1,014,504	2,487,065
Region 70, Los Angeles	278,704	289,159	468,983	296,152	360,785	294,832	224,091	184,074	202,815	209,415
Region 80, San Diego	124,633	183,521	138,475	56,289	33,596	62,544	52,003	75,077	61,924	34,191
State totals	647,297	596,134	850,888	471,030	526,280	555,121	471,861	914,205	7,504,186	9,156,572

were 159,990 pounds, of which Monterey contributed 3170 pounds annually. The amount contributed by the northern portion of the State to the Monterey-San Francisco catch was insignificant. In 1938 the catch in central California was 6,224,883 pounds and Monterey contributed 1,765,845 pounds to this total. A study of table 1 will show the comparative landings for each area from 1930 to 1939. Since the expansion of the fishery in northern and central California, this area now takes 71 per cent of all sharks caught in State waters, leaving only 29 per cent for the southern part of the State.

What the future holds for the industry is unpredictable, and the author not being gifted with the ability of a Yogi for crystal gazing, can only say that in the past shark fisheries have been distinguished for a meteor-like rise followed by an equally sudden eclipse, as the sharks seem not abundant enough to maintain a large annual catch.

REGULATIONS

Shark Fishing

A special permit is required to fish for sharks in San Francisco Bay in order to prevent the capture of game fish. Fishing must be by hand line and set line; only hard-salt bait may be used. The use of ines with hard-salt bait will not as a rule take the more valuable fish. The only fish that may be retained are sharks, skates and rays. All permittees shall have commercial fishing licenses.

Reduction Permits

In a letter to the industry from the Division of Fish and Game appears the following statement:

"Under a recent ruling of the Attorney General, a permit as provided for under Section 1068 of the Fish and Game Code must be secured from this Commission to take and use sharks for the manufacture of (liver) oil. Permits issued under this ruling will provide that sharks may be received, directly from fishermen or through agents acting for the permittee, for the manufacture of liver oil. The permits will also provide that after the removal of the liver the permittee may use the carcass in the manufacture of fishery products or dispose of them to other plants for reduction purposes.

"The permittee shall pay the privilege tax of two and one-half (2½) cents per hundred pounds or fraction thereof on all sharks received directly from fishermen or through his agents and the poundage shall be computed on the whole shark before the removal of the liver.

"Plants not holding shark reduction permits must satisfy themselves that persons or plants from whom they receive shark carcasses, after removal of the livers, are in possession of a permit from this Commission, or are acting as agents of a permittee, as it will be a violation of the law to receive for reduction purposes, sharks or their carcasses, for which a permit has not been issued."

THE APPLICATION OF SARDINE LIFE-HISTORY TO THE INDUSTRY[1]

By Frances N. Clark
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Division of Fish and Game

Along the shores of the Pacific coast of North America is found a herring-like fish that rejoices in several names. From British Columbia to Lower California, fishermen catch it by the ton to be used for canning, for the manufacture of fish meal and fish oil, and for bait in the pursuit of other fish. To the Mexicans this fish is a sardine and to Californians it is also a sardine as a rule, but occasionally the term pilchard is bandied about. In Oregon and Washington the name sardine is seldom mentioned and pilchard comes into common usage, whereas the Canadians of British Columbia, true to their British origin, call this fish pilchard exclusively. This confusion of names merely reflects a similar situation in Europe, where a related fish is known as sardine in the Mediterranean and along the Spanish and French coast but as pilchard in the British Isles. The scientist, who in his inordinate pride considers that he can invent names with worldwide application, fused the two common European names and called the European fish *Sardina pilchardus*. The similar but somewhat different form taken in the Pacific waters off North America, he called *Sardinops caerulea*. *Sardinops* means sardine-like and *caerulea* is derived from the azure color of the fish.

Off the coast of Japan is found another sardine closely related to the North American form but sufficiently different for the scientist to consider it a different species and call it *Sardinops melanosticta*. Also along the Pacific shore of South America occurs a third species, *Sardinops sagax*. The Japanese and South American sardines are separated from the North American form by impassable barriers, either by waters too warm or too cold for the sardines to pass through. Thus the three forms do not intermingle and each supports a separate fishery.

The Gear

A net is the most successful type of gear for catching sardines along the North American coast. In the Nineties and until after the turn of the century, gill nets and round haul nets were both used. In more recent times the round haul net, either purse seine or lampara, has entirely supplanted the gill net. The efficiency of the purse seine depends on the fact that the lead line can be quickly "pursed up" after

[1] Submitted for publication, November, 1939.

a school of fish is encircled. This is done by an especially designed purse line running through rings fastened to the lead line. The purse seine is a large net up to 300 fathoms in length and can surround a hundred tons or more of fish in one set. The lampara, a much smaller net, is operated without a purse line and is so constructed and operated as to herd the fish into a bag in the center of the net. For small fish, especially those which must be handled carefully and kept alive for use as live bait, the lampara is the more popular gear. It is satisfactory only near shore for in deeper water the fish can escape under the lead line of the lampara before the net can be closed. For the offshore fishery and to supply the vast tonnages demanded by the present industry, the purse seine is employed.

The Fishing Season

Using the type of round haul net most suited to each locality, fishermen pursue the sardine throughout its range from British Columbia to the tip of Lower California. In each region the fishery is seasonal in character. Off the coasts of British Columbia, Washington and Oregon the sardines are taken during the summer months, from June through September or October.

Sardines are not sought off the coast of northern California, but off central California, in the neighborhood of the ports of San Francisco and Monterey, sardines are fished from August to mid-February. Although these dates, marking the opening and closing of the central California fishing season, are set by law, the dates August 1 to February 15 also embrace the time interval when sardines can be found in this locality in sufficient abundance to maintain a major industry.

In southern California, from Point Conception to the Mexican boundary, the sardine season extends from November 1 to March 31. As in central California these dates are fixed by law and November 1 marks the approximate date when sardines can first be taken in quantities. On the other hand, the season closes on March 31, not because fish can not be found in April and May but because the sardines are no longer suitable for processing. By the latter part of March sardines are near to sexual maturity. This makes the fish soft and unsatisfactory for canning or reduction into fish meal or oil. The adults do not disappear from southern California waters until about June. In Mexican waters the fishery for adult sardines is too meager to permit the delimitation of seasons.

In both Mexico and southern California many young sardines are used for bait and this fishery extends throughout the year in accordance with the needs of other fisheries. In southern California the heaviest fishing occurs throughout the summer months to supply the summer sport fishing in that area. In Mexican waters young sardines are used as tuna bait throughout most of the year.

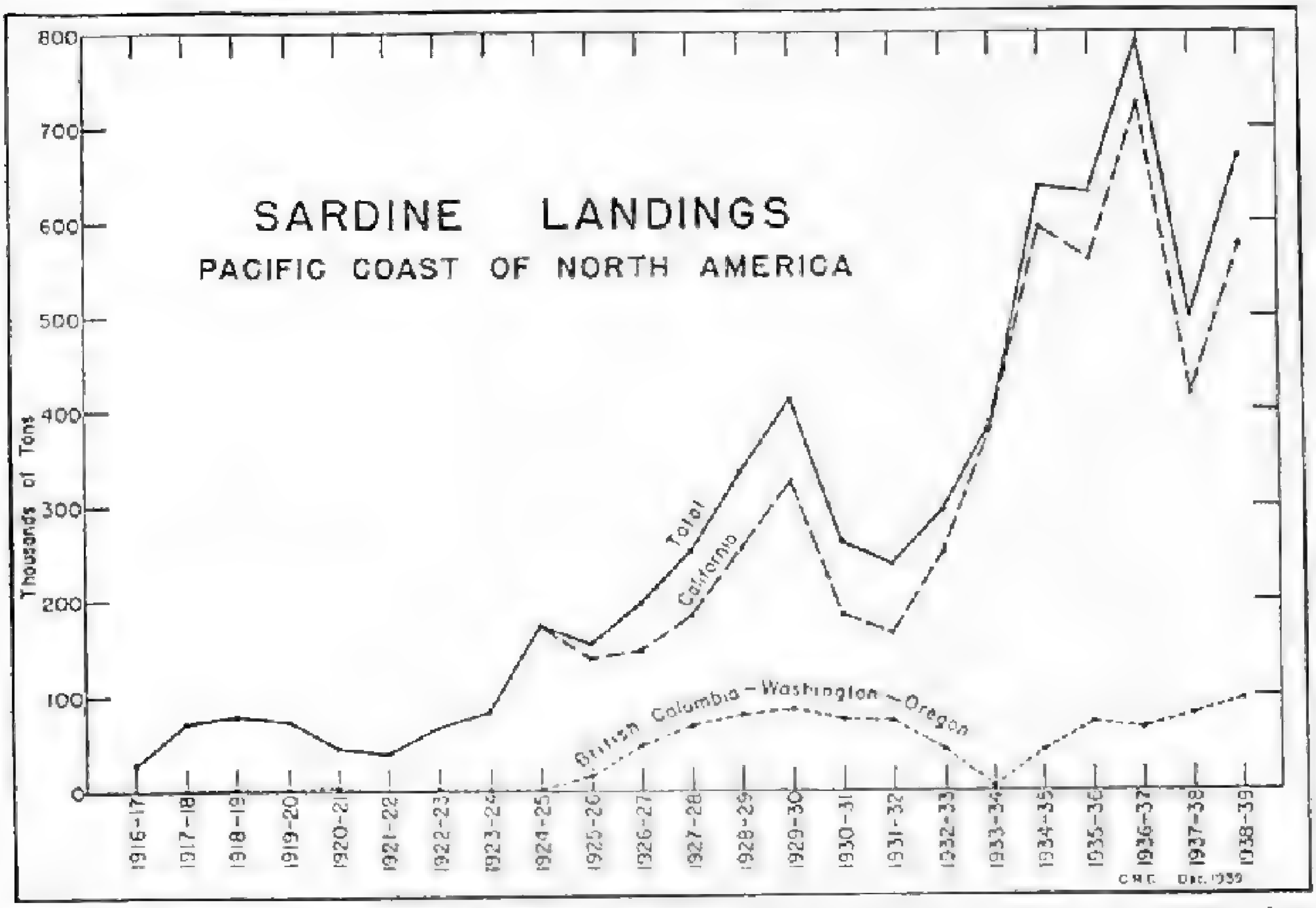

FIG. 16. Seasonal changes in the amount of sardines used for canning and reduction along the Pacific coast of North America. Each season includes June to the following May. The California catch comprises tonnages delivered to shore and floating plants.

The Size of the Catch

In terms of world fisheries and their history, the exploitation of the Pacific sardine along the North American coast is very recent. In the early Nineties the first canneries were established in California. These canneries took only small tonnages and, with a limited fresh fish trade, constituted the industry for about two decades. Then began a rapid expansion with the increased demand for fishery products during the World War from 1914 to 1918, and with the discovery that the most lucrative phase of the industry lay in the reduction of sardines into meal and oil.

In British Columbia the industry has been largely built on a reduction basis and in Washington and Oregon entirely so. The California Division of Fish and Game realizing that a too rapid development held many potential dangers both economic and biologic, attempted to hold its industry to a reasonable growth by limiting the amount of whole fish which could be used for straight reduction. Although fraught with many difficulties and legal disputes, this policy served its purpose with fair success until 1930. This date marks the beginning of a successful evasion, by floating factory ships, of the California restrictions on reduction of whole sardines into meal and oil. These ships, operating off the central California coast beyond the three-mile limit, proved successful and their catch reached large proportions.

A record of the catch, exclusive of the southern California and Mexican bait fisheries, is given by geographic regions in table 1, but

any discussion of statistics of the catch must be based on an understanding of the fishing seasons. Because sardines are not taken in all localities at all times of the year, a presentation of the record of catch can not conform to the calendar year. In the northern part of the sardine's range, off British Columbia, Washington and Oregon, fishing occurs in the summer, and in California in the fall and winter. The tonnages taken in the northern fishery can be compared, therefore, with the amounts taken in California in either the preceding or the succeeding fall and winter. In table 1 the statistics have been compiled according to the time interval from June to the following May 31. This compares the British Columbia, Washington and Oregon summer fishery with the succeeding fall and winter fishery in California. It also comprises a biological year for the sardine, as spawning occurs in the spring.

In no region are accurate figures available before 1916-17 when the records show less than 30,000 tons taken in California and none in British Columbia. The industry in British Columbia began in 1918-19, reduction started in 1924-25, and the fishery reached its peak in 1929-30 when 86,000 tons were taken. For the last five seasons the catch has varied between forty and fifty thousand tons. In Washington fishing did not begin until 1936-37 and the largest catch of 26,000 tons was made in 1938-39. Oregon fishermen first operated in 1935-36 and made their largest catch, 26,000 tons, in the first season of operation.

In California the tonnage delivered to shore plants has experienced some fluctuations but in general the catch has increased season by season to an all time high of 530,000 tons in 1938-39. The catch of the California floating plants, on the other hand, rose rapidly to a maximum of almost 236,000 tons in 1936-37 and decreased thereafter. This decrease was due to increased labor costs, more strict maritime regulations and greater scarcity of fish. No records are available for the amounts taken in Mexican waters except for 1938 when 2160 tons were landed. This small tonnage indicates the very minor role that the Mexican canning and reduction industry has played in the sardine fishery. The consistently large tonnage taken by California fishermen year after year demonstrates, on the other hand, how important is the catch from California waters. Only once in the past 23 seasons have the California landings been less than 70 per cent of the total for all localities. In 1931-32 the catch was 69 per cent. In 17 seasons the California tonnage was greater than 80 per cent of the total and in 13 seasons more than 90 per cent.

The explanation of this large California catch, which for the past 15 seasons has not been less than 130,000 tons, and the much smaller catches from other regions, whose combined total in any season has never reached 100,000 tons, lies in the behavior of the sardines. These fish are found in California waters for a longer time interval each season than in any other locality. In addition, fish of all sizes occur off the California coast, whereas only the largest sizes are found in the northern portion of the sardine's range and only the smaller sizes in the southern portion. This peculiar distribution of the sardines in its turn evolves around the life-history of the species.

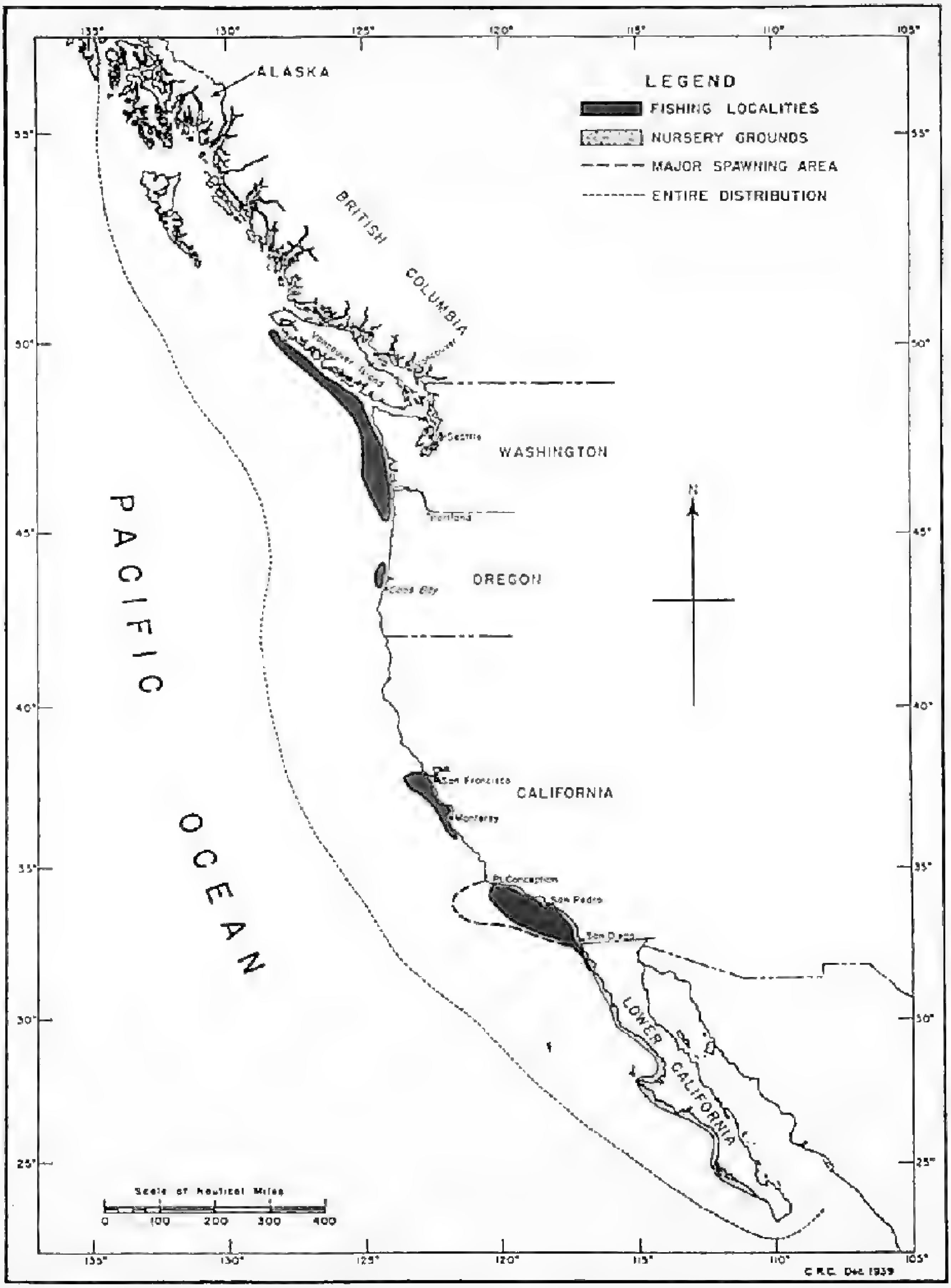

FIG. 17. Map showing diagrammatically the distribution of the sardine, the major spawning area, the chief nursery grounds and the fishing localities. The size of the fishing area in each locality bears no relation to the amount of fish caught in the different localities.

The Life-History

Spawning takes place from February to July, the peak occurring in April and May. The chief spawning area lies off southern California between Point Conception and San Diego. Some fish spawn in inshore waters but many more in waters well offshore beyond the Channel Islands. A fair amount of spawning occurs off the Lower California coast and in these regions reproduction may begin earlier than February. In some seasons, especially during warm years, sardine eggs have been found as far north as central California. As yet no sardine eggs have been recorded north of California but more exploratory work may reveal some spawning in these northern regions with increased amounts during warm springs and summers. In this portion of the sardine's range spawning may continue later than July. The optimum temperature for spawning lies between 14° and 18° C. (57.2° and 64.4° F.) and this probably explains the concentration of spawners in the south central portion of the range of the species. Waters to the north are too cold and those to the south too warm.

Sardine eggs are extruded by the females into the sea where they are fertilized by the milt simultaneously emitted by the males. The fertilized eggs float freely near the surface of the water and hatch in two or three days. The larval fish, drifting with the currents, are carried toward the sandy beaches, off which lie the nursery grounds for young sardines. These young fish ranging in size from a few millimeters to 150 mm., standard length,[2] or 7 inches, total length, are found in large numbers along the beaches of Lower California and off California south of Point Conception. In central California, especially Monterey Bay, fish of these sizes are also quite numerous. Off northern California, Oregon, Washington and British Columbia only scattered records of their occurrence are available; similarly to the south in the Gulf of California. In spite of these indications of an extensive distribution of young sardines, the consistent occurrence and overwhelming numbers of young fish south of Point Conception establish the chief nursery grounds in the waters off southern California and northern Lower California.

The length of time that the young fish remain on each nursery ground before moving to another locality has not been determined. It may be only a month or two or it may be as much as six months. Circumstantial evidence indicates, however, that the young fish early manifest the roving tendency which is to characterize the later years of their life. Movement between adjacent localities probably takes place during the first few months, and within their first year the young fish may have experienced a movement of several hundred miles. In each locality the smallest fish are found close to shore, and as they increase in size they tend to work into deeper waters.

A few sardines become mature when they are about 160 mm., standard length (7.4 in., total length), about 50 per cent of the population is mature at 180-190 mm., and practically all fish spawn at 210 mm., standard length (9.7 in., total length). Accurate age determination for the sardine has proved difficult but probably a small percentage

[2] Standard length is measured from the snout to the base of the tail; total length to the end of the tail.

of the population spawns at the end of the second year, about half at the end of the third year and nearly all at the end of the fourth.

For the past twenty years the possibility that sardines make annual migrations up and down the Pacific coast of North America has been discussed. Only the largest fish are found in abundance off the coasts of Oregon, Washington and British Columbia, and they are found in these waters only during the summer and early fall months. In California the largest fish occur throughout the winter and spring. They enter the central California fishing grounds a month earlier than the southern California grounds, about December and January, respectively. In keeping with their earlier appearance in central California, the large fish disappear from these waters sometime in March but remain off southern California through the spawning season and disappear in May or June. The smaller sardines, adolescents and young adults, are also found in central and southern California waters in the fall, winter and spring months, but most of them leave the California fishing grounds during the summer.

These, as well as other facts, indicate a yearly journey northward during the summer and southward throughout the fall and winter to the spawning grounds in southern California waters. The final demonstration of this migration was made by the recovery of tagged fish. Sardines tagged off southern California in February and March have been retaken off British Columbia the following July and August. Conversely, fish tagged off British Columbia in July and August have been recovered off central California in December and January and off southern California in February and March. Similar exchanges have occurred between the California and Washington and Oregon fisheries and between central and southern California. Furthermore, sardines of many sizes have been tagged in California waters but only the largest fish have been retaken north of the San Francisco region. On the other hand, the small as well as the large fish have interchanged between central and southern California. The tagging program has been carried on since 1936 and this interchange of fish has occurred each year.

Thus the movements of the sardine may be summed as follows: Most of the adults collect to spawn in southern California waters from March to June. The young fish remain on the nursery grounds in southern California and northern Lower California for perhaps six months or a year. In their second summer, if not earlier, they exhibit some northward movement and the extent of this northward movement increases year by year. The largest and oldest fish reach the waters of British Columbia, Washington and Oregon. This summer northward migration is followed by a southward return in the fall and winter preparatory to the spring spawning.

This annual migration explains why California fishermen are able to take so much greater tonnages than can the fishermen in other areas and why California has been able to develop so many more processing plants. All regions are drawing from the same sardine population but this population is not equally distributed throughout its range. Small sardines are found in California waters throughout the year, adolescent and young adults during the fall, winter and spring, and the largest adults in the winter and spring. North of California the small sar-

dines are apparently very rare, the young adults are scarce and only the oldest adults are abundant. In addition these oldest fish are summer and early fall visitors only and disappear, with the exception of an insignificant portion, for the remainder of the year. Thus, because of the movements of the sardine population, California has a fishing season for adolescent and adult fish of eight months as contrasted with a season of three to five months for British Columbia, Washington and Oregon. The abundance of adult sardines in Mexican waters is not known with any exactitude, but it appears to be much less than in California waters. The California fishermen are blessed with fishing grounds located in the center of the sardine's range.

The Food

Sardines have practically no teeth, or if teeth are present they are too feeble to be of use in obtaining food. Because of this lack, these fish must feed on minute plants and animals which float in the water and are known collectively as plankton. The sardine takes sea water in through its mouth and passes it out over its gills. At the base of the gills, on the arches to which the gills are attached, is developed an elaborate straining apparatus which catches the tiny plants and animals in the sea water and permits their passage into the stomach, while the sea water continues out over the gills.

When the fish are very small, in the larval stage, this straining apparatus is imperfectly developed and will strain out only the larger planktonic forms, mostly animals. As the strainer elaborates with the growth of the larva, more and more minute forms are retained and the sardine is able to include both plants and animals in its diet. Soon nearly all plankton available in the area where the sardine is feeding is incorporated in its food.

Planktonic plants and animals are not equally distributed throughout all parts of the sea nor are they equally numerous in any one locality at all seasons of the year. The presence or absence of abundant food probably plays an important role in the annual migration of the sardine. It definitely affects the amount of fat which the fish are able to store—if food is scarce sardines will be in poor condition. In addition the type of plankton available is of equal importance with its abundance. Certain forms, animals rather than plants, contain much oil and when these forms are plentiful in the plankton the sardines will wax fat and when scarce the fish will be lean.

The Oil Yield

As stated above, the most lucrative phase of the sardine industry is the extraction of oil from the whole fish. The success of a fishing season is at times measured by the amount of oil produced and unfortunately this factor varies from season to season and from locality to locality. Why this variation occurs seems mysterious to some but the answer is relatively simple. The amount of oil a ton of sardines will yield is dependent on the amount of fat stored in each fish. The quantity of fat stored is in its turn dependent on the amount and type of food available to the sardine. This varies from season to season and

explains the seasonal variation in oil yield. The variation in oil yield between localities is caused by more complex factors. Each individual fish experiences a seasonal cycle of fat storage and fat loss, with the large fish storing more fat than the small fish. At the close of the spawning season the fat reserve has been completely exhausted and the fish is very lean. During the northward migration, however, the fish finds rich feeding grounds and the fat reserve is quickly restored. Because sardines taken off British Columbia, Washington and Oregon are large and because they come from rich feeding grounds, the oil yield of these fisheries is high, especially in the late summer. In the early summer, due to the short time since spawning, the fat reserve has not been built up and the first part of the northern season is at times handicapped by a poorer return. In general, however, the oil yield from the British Columbia, Washington and Oregon fishing grounds is higher than from any other locality.

Off central California the oil content, although somewhat less than farther north, is equally satisfactory during the fall and early winter. As the spawning season approaches the stored fat is used for the maturing of the sex products, and the oil yield decreases throughout the winter in central California. In the southern California fishery the oil return is always notably less than in the other localities. This is due to two causes. The fish taken in the fall are smaller than in other regions and consequently have a lower percentage of fat. Those taken in the winter, although they are as large as on other fishing grounds, are too near to spawning and have dissipated their fat supply. Again it is the life-history and the movements of the sardine that determine the amount of oil per ton that will be extracted in each fishing region.

Acknowledgments

The material presented in this paper has been drawn from many sources. The life-history is summarized from the works of the California Division of Fish and Game, the Fisheries Research Board of Canada, and the Department of Fisheries of British Columbia. The Department of Fisheries of Washington and the Fish Commission of Oregon have contributed to the tagging program. The statistics of the catch have been supplied by the Canadian Bureau of Statistics, the Washington Department of Fisheries, the Oregon Fish Commission, the United States Bureau of Fisheries, the California Division of Fish and Game, and the Department of Forestry, Game and Fish of Mexico.

Detailed reports of the studies on the sardine may be found in the "Fish Bulletins" and in "California Fish and Game," both series published by the California Division of Fish and Game. The investigations carried on by Canada have been reported in "Contributions to Canadian Biology" and "Bulletins" of the Fisheries Research Board of Canada, in the "Progress Reports" of the Pacific Biological Station of Nanaimo, and in the "Reports" of the Provincial Fisheries Department of British Columbia.

TABLE 1

Seasonal Catch in Tons of Sardines Used for Canning and Reduction to Oil and Meal Along the Pacific Shores of North America. Each Season Includes June to the Following May

	British Columbia	Washington	Oregon	California shore plants*	California floating plants	California total	Total
1916-1917	....	....	....	27,540	....	27,540	27,540
1917-1918	80	....	....	72,140	....	72,140	72,220
1918-1919	3,640	....	....	76,020	....	76,020	79,660
1919-1920	3,280	....	....	70,810	....	70,810	74,090
1920-1921	4,400	....	....	41,840	....	41,840	46,240
1921-1922	990	....	....	38,500	....	38,500	39,490
1922-1923	1,020	....	....	65,110	....	65,110	66,130
1923-1924	970	....	....	83,920	....	83,920	84,890
1924-1925	1,370	....	....	173,030	....	173,030	174,400
1925-1926	15,950	....	....	137,890	....	137,890	153,840
1926-1927	48,500	....	....	147,230	....	147,230	195,730
1927-1928	68,430	....	....	183,270	....	183,270	251,700
1928-1929	80,510	....	....	254,530	....	254,530	335,040
1929-1930	86,340	....	....	325,210	....	325,210	411,550
1930-1931	75,070	....	....	174,160	10,960	185,120	260,190
1931-1932	73,600	....	....	133,610	31,040	164,650	238,250
1932-1933	44,350	....	....	191,900	58,790	250,690	295,040
1933-1934	4,050	....	....	315,610	67,820	383,430	387,480
1934-1935	43,000	....	....	483,010	112,040	595,050	638,050
1935-1936	45,320	....	26,230	409,670	150,830	560,500	632,050
1936-1937	44,450	6,550	14,200	490,510	235,610	726,120	791,320
1937-1938	48,050	17,200	16,660	348,980	67,580	416,560	498,500
1938-1939	51,770	26,450	16,990	531,400	43,890	575,290	670,530
Totals	745,170	50,230	74,080	4,775,890	778,560	5,554,450	6,423,930

*Includes relatively small amounts delivered to fresh fish markets.

CALIFORNIA SALMON CATCH RECORDS[1]

By G. H. Clark
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Division of Fish and Game

The salmon fishery in California, once considered one of the State's major industries and outranking the other fisheries, has diminished to the point where by comparison there is now very little remaining. The decline has been due to a number of causes as shown by the investigations carried on since the nineteenth century. As a result of these studies, legislative measures have been enacted over a long period of years. The conservation laws have gradually restricted commercial salmon fishing to only one river and several ocean districts, in an attempt to halt the decline and rehabilitate the salmon population. With the inception of the California Fish and Game Commission in 1872, the salmon was one of the first fisheries to be investigated, and since that time numerous reports giving the results of these studies have been published. In addition, statistical records of the commercial salmon catch have been collected for many years, but these statistics are in various publications and in various forms of presentation. It is the purpose of this paper to bring together all the known and scattered records of commercial catches of salmon in California and to present a summary of the innumerable laws enacted for the conservation of the species.

Salmon fishing began in the rivers of California, first in the Sacramento River and then in the other streams—Klamath, Smith, Eel and Mad rivers, and even some of the smaller creeks. Records show that fishing on a commercial scale was carried on by means of beach seines and gill nets as early as 1850 in the Sacramento and San Joaquin rivers and the San Francisco Bay area. About 1900 salmon fishing with troll lines was introduced in the ocean waters of Monterey Bay. Gradually, ocean fishing spread northward from Monterey to San Francisco, then to the waters off Fort Bragg, Eureka and Crescent City. As ocean trolling developed, some of the rivers were closed to commercial fishing by the Legislature; first, the Mad River was affected, then the Eel and finally the Klamath and Smith rivers. (See Figs. 23 and 24.)

Commercial fishing in the rivers of California has always been conducted by means of either drift gill nets or by beach seines, with various legal restrictions. The gill nets usually were of linen twine with mesh sizes between seven inches and nine inches long, stretched measure. These nets varied in length and depth, depending upon where they were used. The seines, which are no longer legal, were made of cotton twine,

[1] Submitted for publication, December, 1939.

sometimes tarred, and like the gill nets varied in length and depth according to the particular hauling ground at the locations where they were fished. All ocean fishing for salmon has been with troll lines. Each line has several brass spoons attached to wire leaders, although occasionally bait (whole sardines or herring) is used instead of spoons. The lines are trolled from outriggers with additional lines directly over the stern, and the spoons are held at various fishing levels by lead sinkers of different weights. The number of lines per boat varies somewhat with individual fishermen, but there has been a tendency to

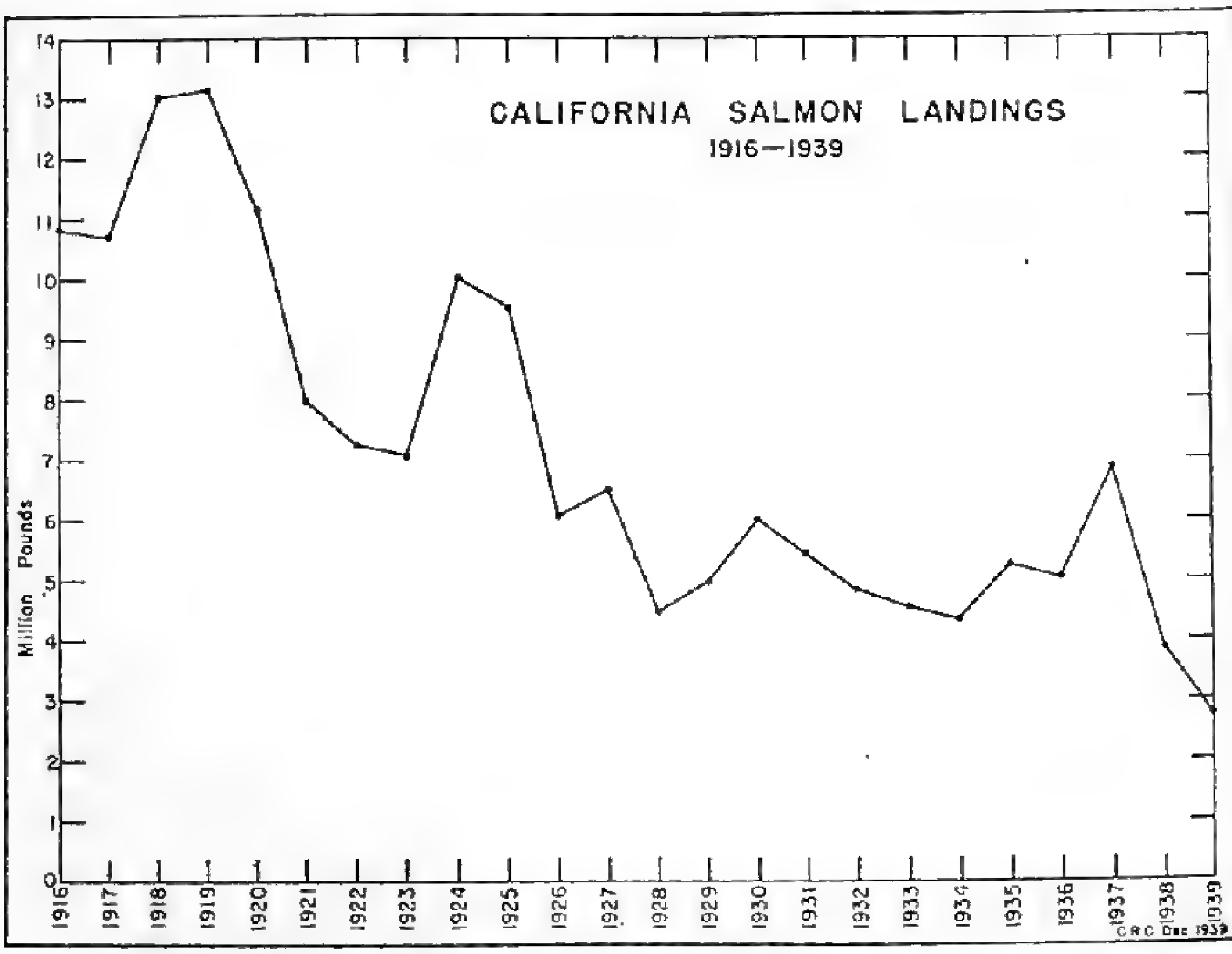

FIG. 18. Salmon landings in California, 1916-1939.

increase the number of lines per boat, and power "catheads" have been adopted on many boats in later years to expedite the handling of the lines. Although the type of boat and gear for ocean trolling has not changed, the number of lines and the method of handling them has changed so that in effect the fishing effort for salmon has increased. This increased effort was offset to some extent in 1931 by the law putting a minimum size limit of 27 inches on king salmon and 24 inches on silver salmon. The size limit has had a tendency to reduce the total catch in pounds landed as well as the catch per boat.

As a part of its program in managing the fisheries on a sound basis, the California Division of Fish and Game has collected complete records of commercial fish catches since 1916. As demonstrated in the accompanying graphs and tables, these figures give a picture of the salmon fishery over a period of more than twenty years.

Sport fishing for salmon is coming to be of increasing importance and anglers are now taking large quantities of these fish. To follow trends of abundance, records of sport catches are essential, in fact with the legislative closure of rivers in California to commercial salmon fishing, it became necessary for the Division of Fish and Game to obtain records of the anglers' catch on these rivers in order to know the condition of the fish populations in the streams. Sport fishing for salmon has been carried on in most of our salmon streams and in certain ocean

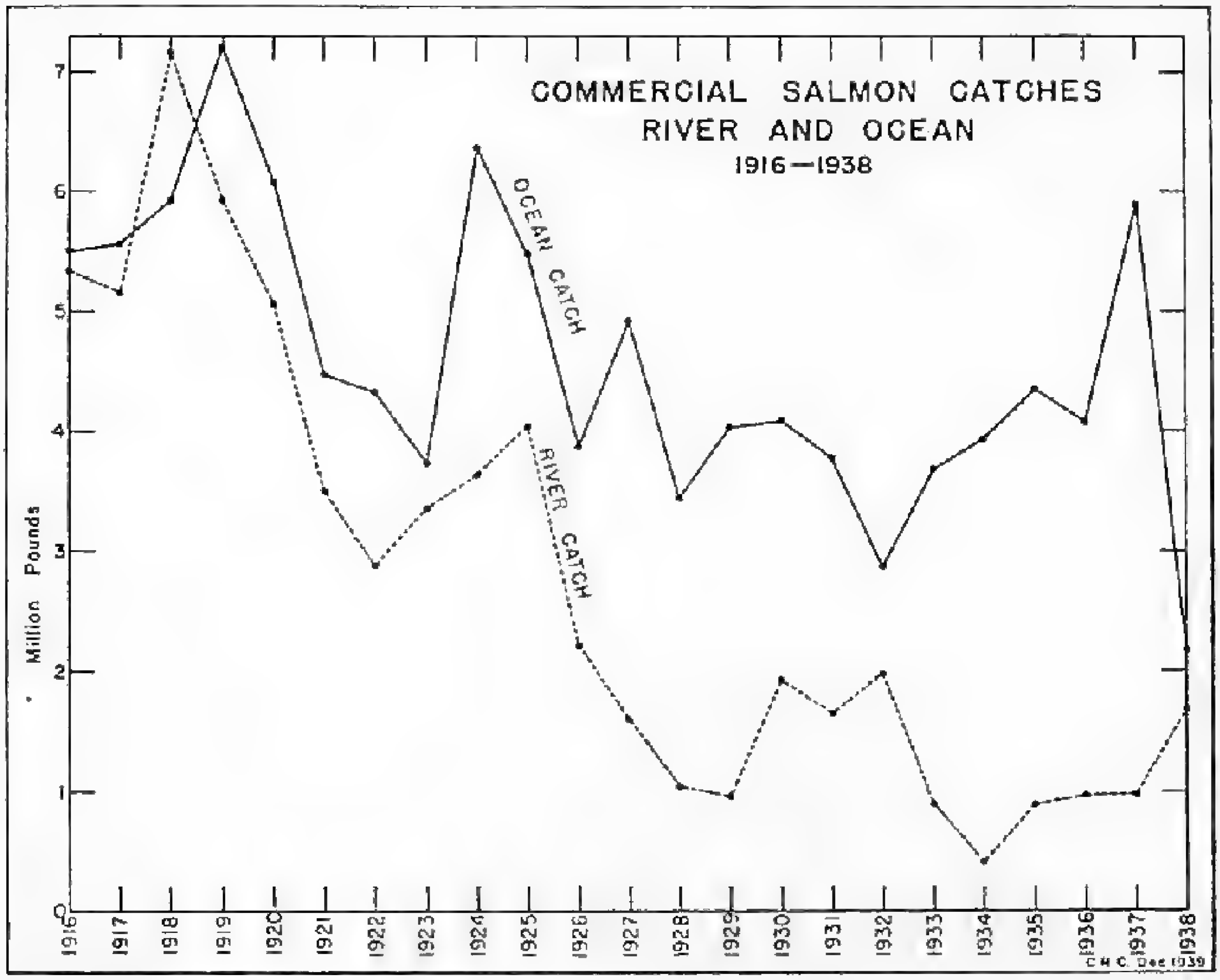

FIG. 19. Comparison of California salmon catches made in the ocean and in the rivers, 1916-1938.

localities for many years, but the collection of sport fishing records is a fairly recent innovation and of course these records are not complete. However, table 14 is presented to show the anglers' catches of salmon actually reported, even though the figures represent only an undetermined proportion of the sport take.

To indicate the past and present importance of the salmon fishery in the various fishing regions, tables showing the total commercial catch by months and by districts for the years 1916 to 1930, inclusive, are appended.[2] The districts shown are Del Norte-Humboldt, which

[2] The salmon fishery statistics presented with this report were taken from the following publications of the California Division of Fish and Game: "California Fish and Game," "Statistical Circulars," and "Fish Bulletins" 15, 20, 30, 34 and 49, but all records have been corrected for previous errors. The changes in salmon legislation were compiled from the California Fish and Game Codes, and for the earlier years from the California Political Code.

includes the coastal area from the Oregon-California boundary to the northern boundary of Mendocino County; Mendocino-Sonoma district, which extends on the coast from the northern boundary of Mendocino County to the southern boundary of Sonoma County; Sacramento River district, which includes the inland waters from Contra Costa County to the upper portions of the Sacramento and San Joaquin rivers; San Francisco district, which covers the coastal waters off Marin, San Francisco and San Mateo counties; and Monterey district, the coastal waters off Santa Cruz and Monterey counties.

Also appended are tables giving the monthly catches of salmon by regions for the years 1931 to 1939, inclusive. In 1931 the Division of Fish and Game changed the method of reporting deliveries by the above mentioned districts to regions. These regions, roughly corresponding to the districts, and divided more or less along county lines, are as follows: Region 10 includes the coastal territory from the Oregon-California boundary to Trinidad Head (Del Norte County); Region 20 extends from Trinidad Head to Point Arena (Humboldt and Mendocino counties); Region 30, the Sacramento-San Joaquin River areas and Suisun Bay; Region 40, coastal areas from Point Arena to Pigeon Point (San Francisco, Marin, Sonoma and San Mateo counties); and Region 50, from Pigeon Point to Point Piedras Blancas (Santa Cruz and Monterey counties).

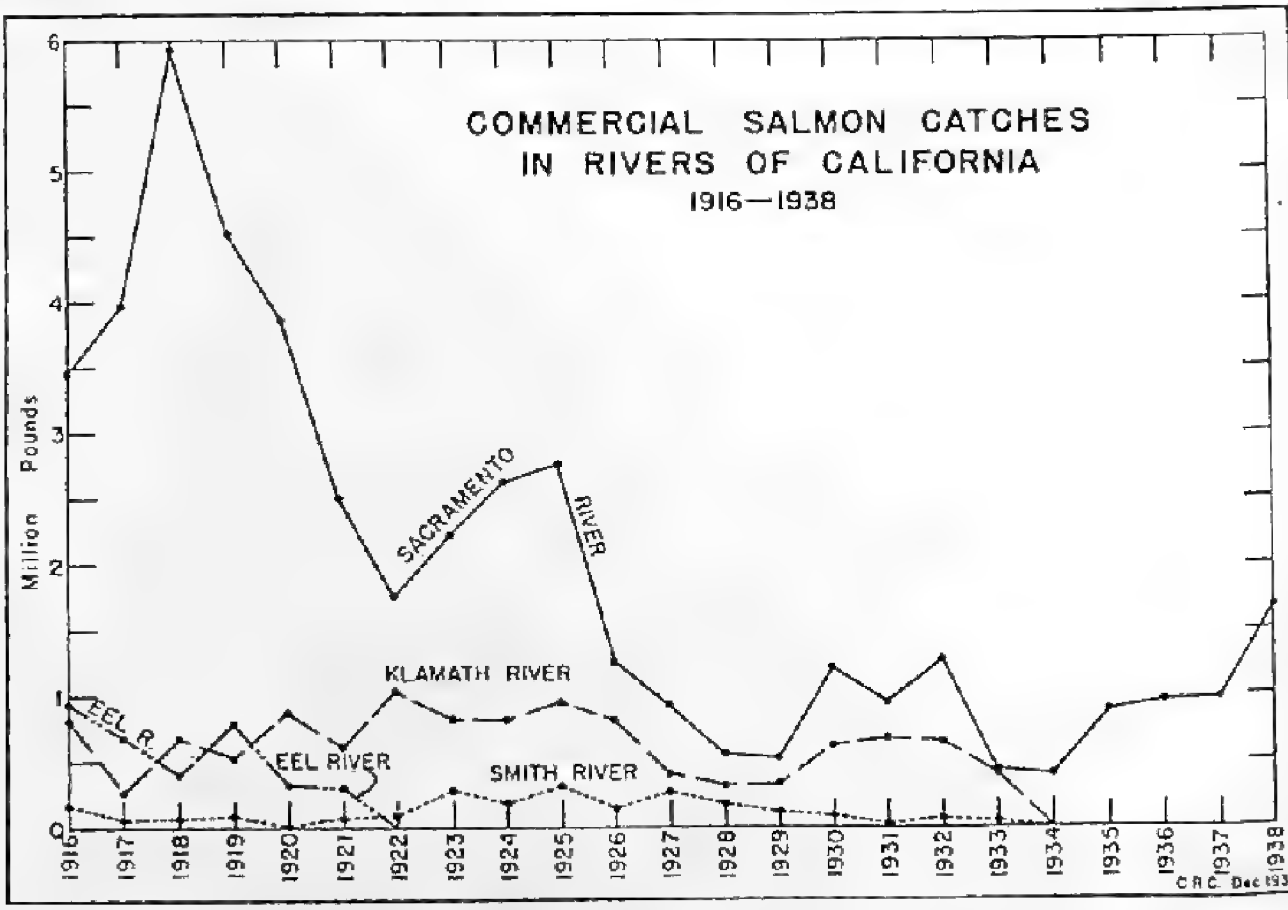

FIG. 20. Salmon catches made in the Sacramento-San Joaquin, Eel, Klamath and Smith rivers, 1916-1938. During this period, commercial salmon fishing was allowed in only one other river, the Mad. Less than 70,000 pounds was caught there in 1918, the last year of fishing, and none in 1916 or 1917.

Other tables are also included which can be used for reference to obtain the annual catch of salmon by rivers as well as by ocean districts.

So far in this discussion there has been no indication of what species of salmon is involved in the California fishery. As a matter of fact several species of salmon occur in the State but only two of the species are of commercial and sport importance in California—these are the king and the silver salmon.[3] The California commercial catch records are not complete in the separation of these two species, so that king and silver salmon are combined into the single classification of "salmon" in the statistical compilations. Some data are available to indicate the proportion of silver salmon in the total salmon catch. However, the figures are not consistent from year to year and from fish house to fish house in the same port during the same year, due to the inaccuracies of the dealers' records, even though all the fishermen presumably draw upon the same schools of fish. As a result of such data, we can only roughly estimate that between 20 and 30 per cent of the total catch landed at ports north of Point Arena are silver salmon and that less than 10 per cent of the salmon catch south of Point Arena is composed of silvers. The entire catch of the Sacramento-San Joaquin river region consists of king salmon, but former commercial and present sport catches in the rivers to the north include both king and silver salmon.

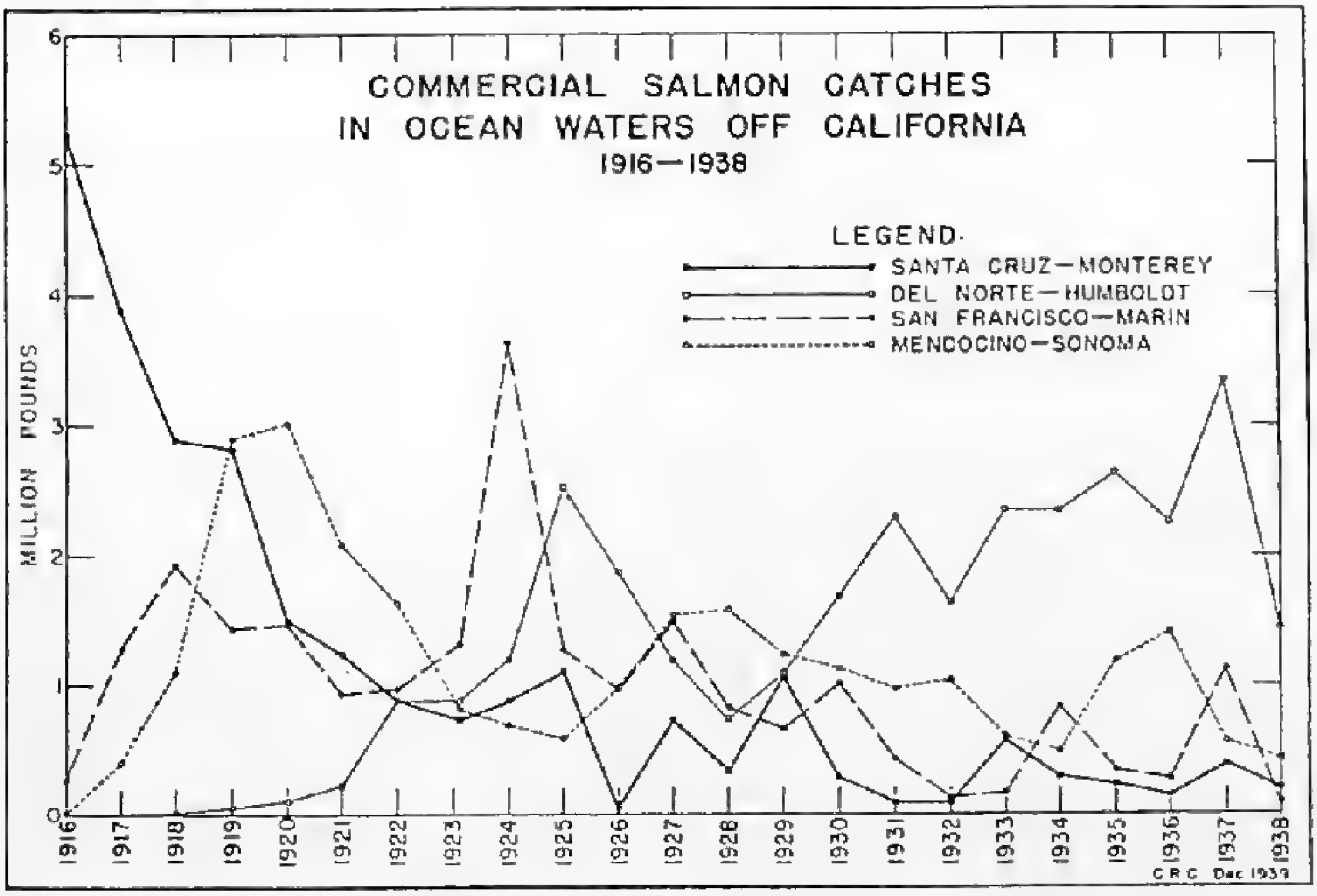

FIG. 21. The ocean catch of salmon in California, by districts, 1916-1938.

Examination of the catch graphs and tables gives an idea of the extent of the salmon fishery, but to complete the picture it is necessary to know something about the complicated legal measures which have imposed restrictions on the fishery.

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[3] The king salmon (*Oncorhynchus tschawytscha*) is also known as chinook, quinnat, spring and tyee; the silver salmon (*O. kisutch*) is also called coho and silversides.

In 1872 the State Legislature prohibited net fishing during part of the spawning period in Siskiyou County. (See Fig. 23.) A general closed season on the taking of salmon during the month of August was established in 1881. In the same year the Legislature prohibited the use of traps, pounds, weirs and set nets, and provided that there should be no net fishing for salmon between sunrise Saturday and twelve o'clock noon Sunday. Since then changes have been numerous. Figures 23 to 26, inclusive, show these changes in graphic form.

Salmon laws, as enacted by the Legislature between the years 1872 and 1915, inclusive, applied to all areas in the State. However, in 1911 the Legislature created the fish and game districts, and in 1915 other districts were created particularly for commercial fishing, so that when laws were later passed pertaining to salmon, reference was always made to the district affected. The accompanying charts showing salmon legislative changes enable one to trace the open and closed seasons in any district. It is noticeable, with a few exceptions, that as the years advanced and the salmon catches declined the Legislature extended the open season for taking salmon. This is a natural result because as the catch decreased, more and more pressure has been brought to bear upon the Legislature to extend the open period on the assumption that the time of salmon runs had altered to earlier or later dates.[4]

During the period of years from 1916 to 1939, inclusive, many restrictions were placed on river fishing so that now all the rivers, except the Sacramento, are closed to commercial fishing. Even in the Sacramento River and the adjacent bay areas, much of the original territory open to commercial fishing for salmon has been closed by the Legislature. (See Fig. 24.) It can be noticed that on the whole, restrictions have become more and more severe in the river districts whereas ocean fishing has had little curtailment.

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[4] By an examination of the curves in figure 22, which show the seasonal catches for two periods, it will be noticed that there has been little change in the time of runs of salmon, either in the rivers or in areas off the coast.

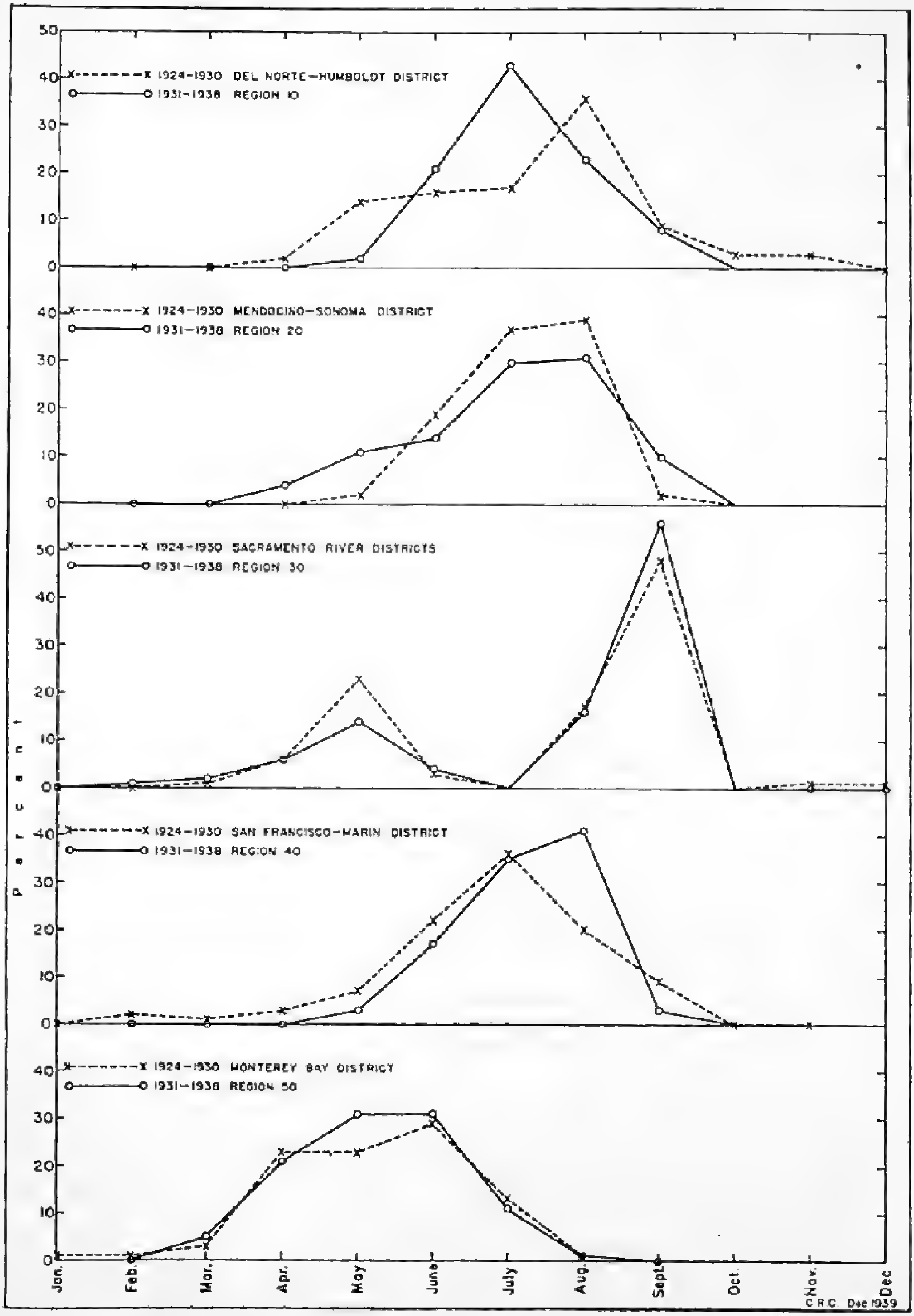

FIG. 22. Comparison of monthly salmon catches for the periods 1924-1930 and 1931-1938, expressed in percentages of the total catch for each period.

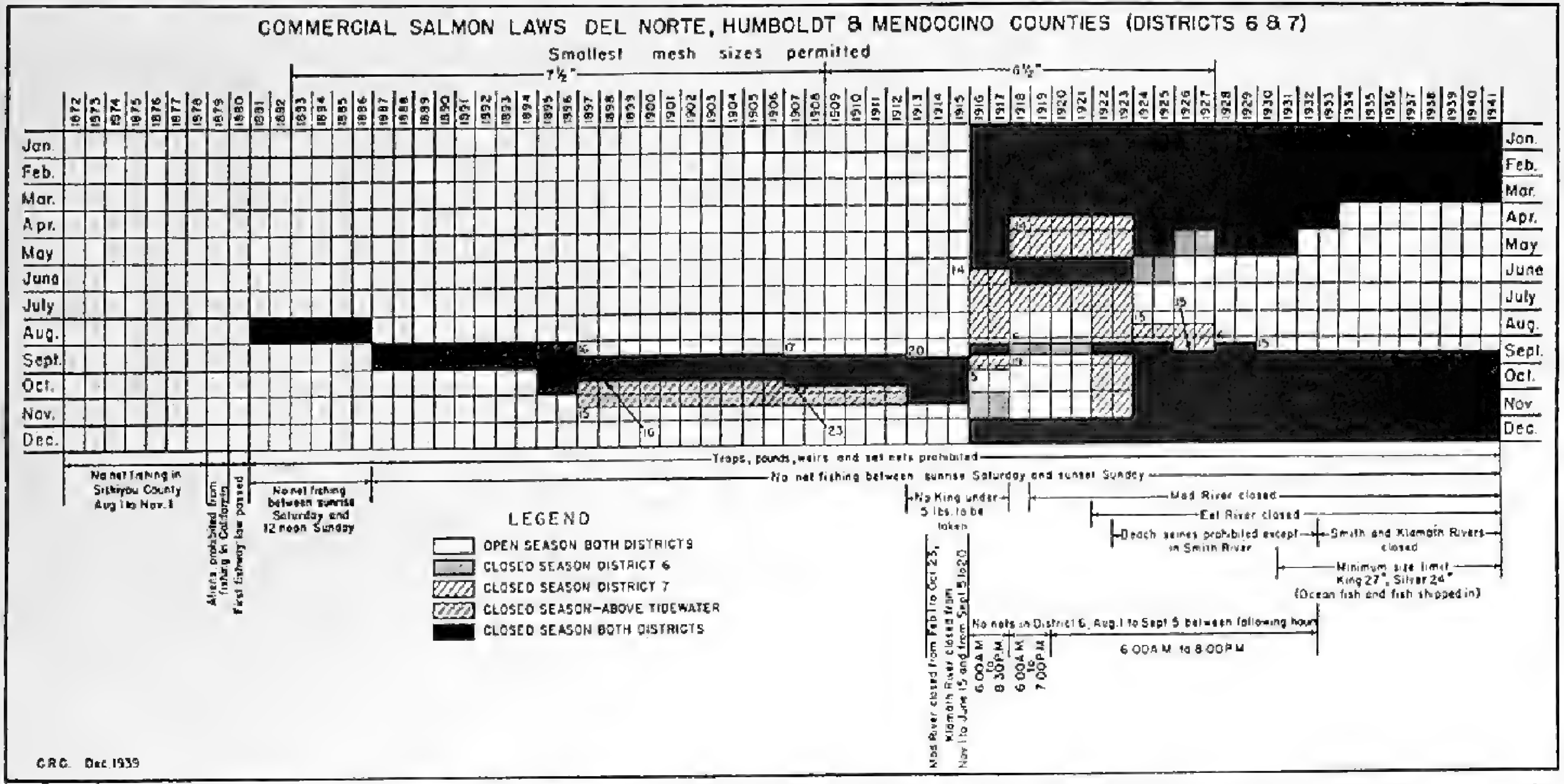

FIG. 23. Chart showing diagrammatically the changes in the commercial salmon laws in Del Norte, Humboldt and Mendocino counties (ocean and river districts) from 1872 until after the adjournment of the 1941 Legislature.

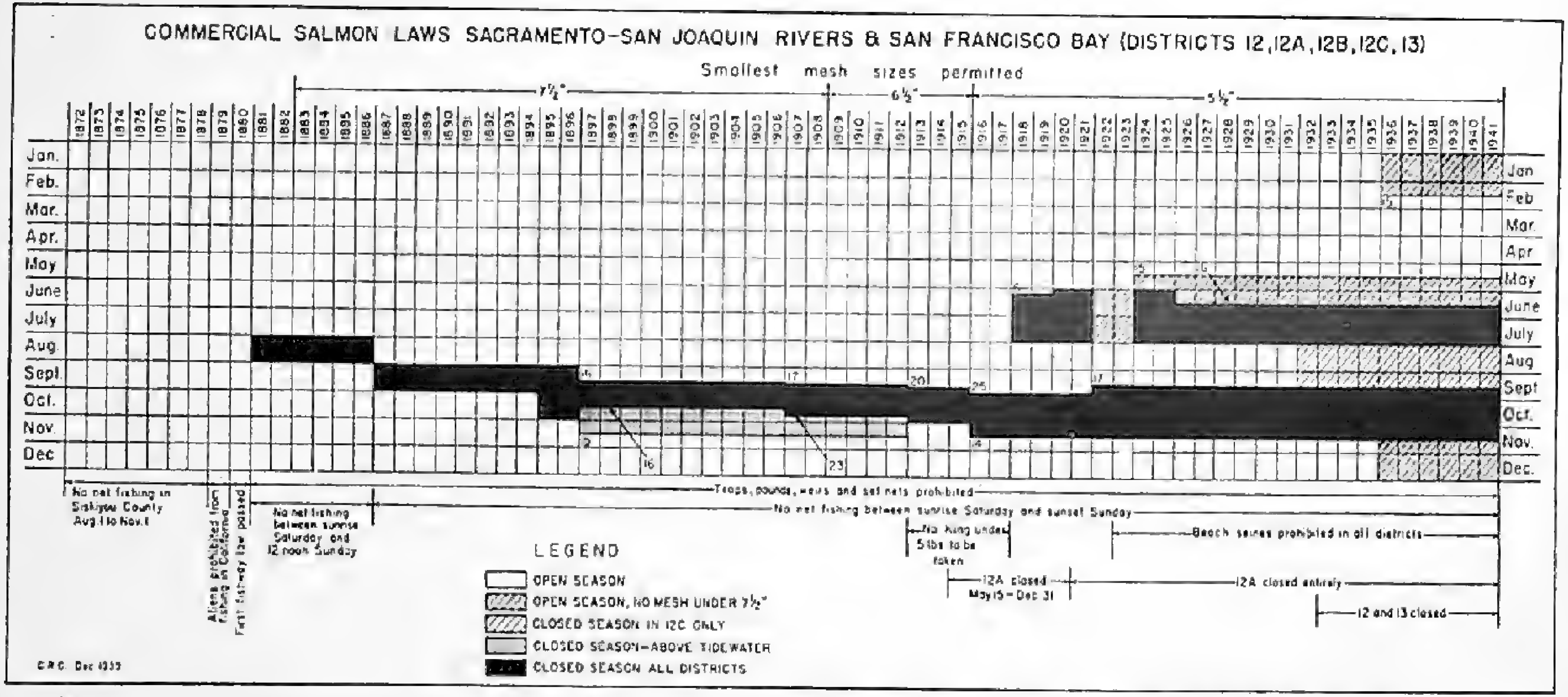

FIG. 24. Chart showing diagrammatically the changes in the commercial salmon laws in the region comprising San Francisco Bay and the Sacramento and San Joaquin rivers with their tributaries from 1872 until after the adjournment of the 1941 Legislature.

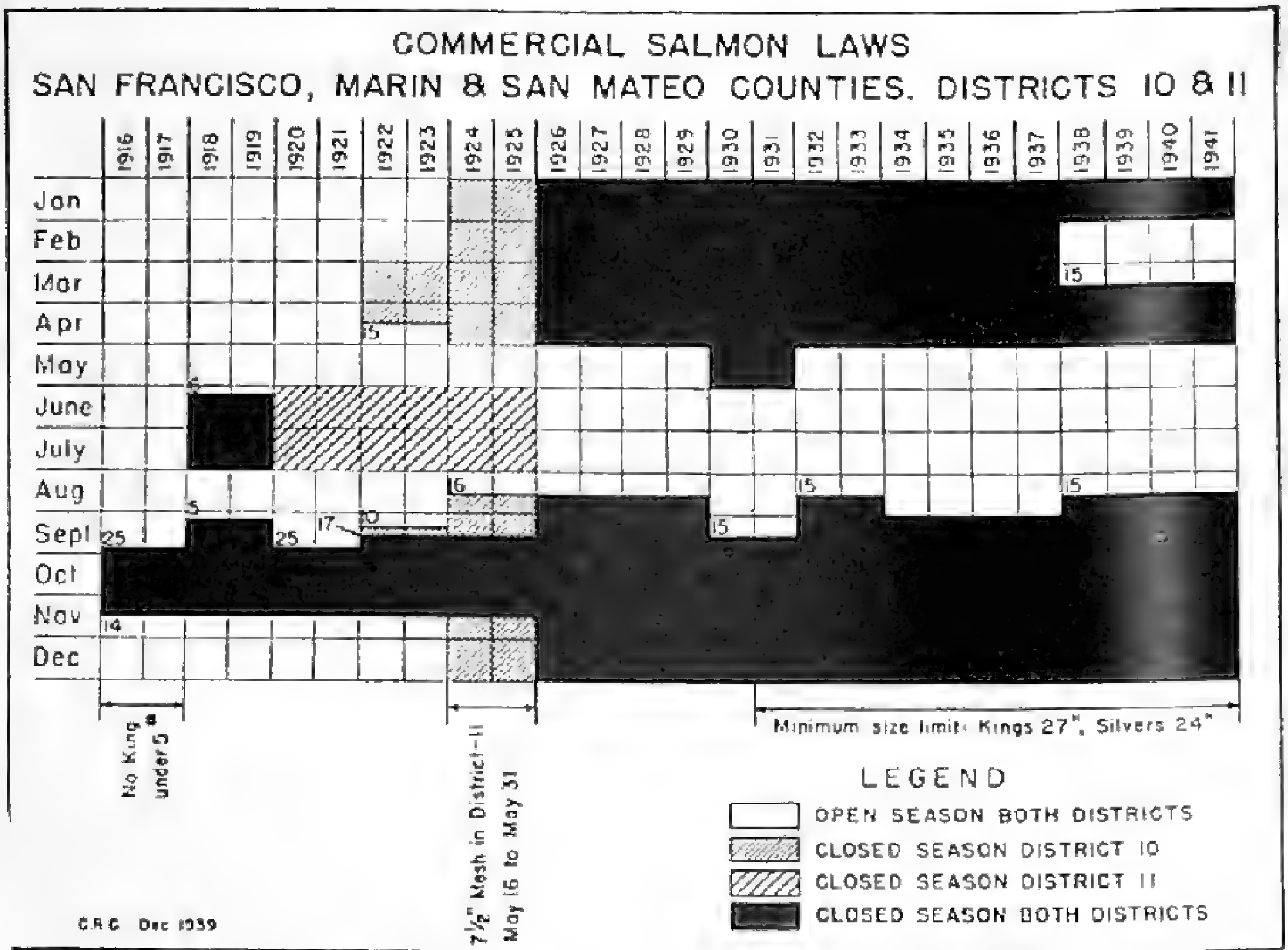

FIG. 25. Chart showing diagrammatically the changes in the commercial salmon laws in the ocean districts of San Francisco, San Mateo, Marin and Sonoma counties, from 1916 to 1941. Prior to 1916 there were no special laws for these districts, and state-wide laws prevailed (see Fig. 23).

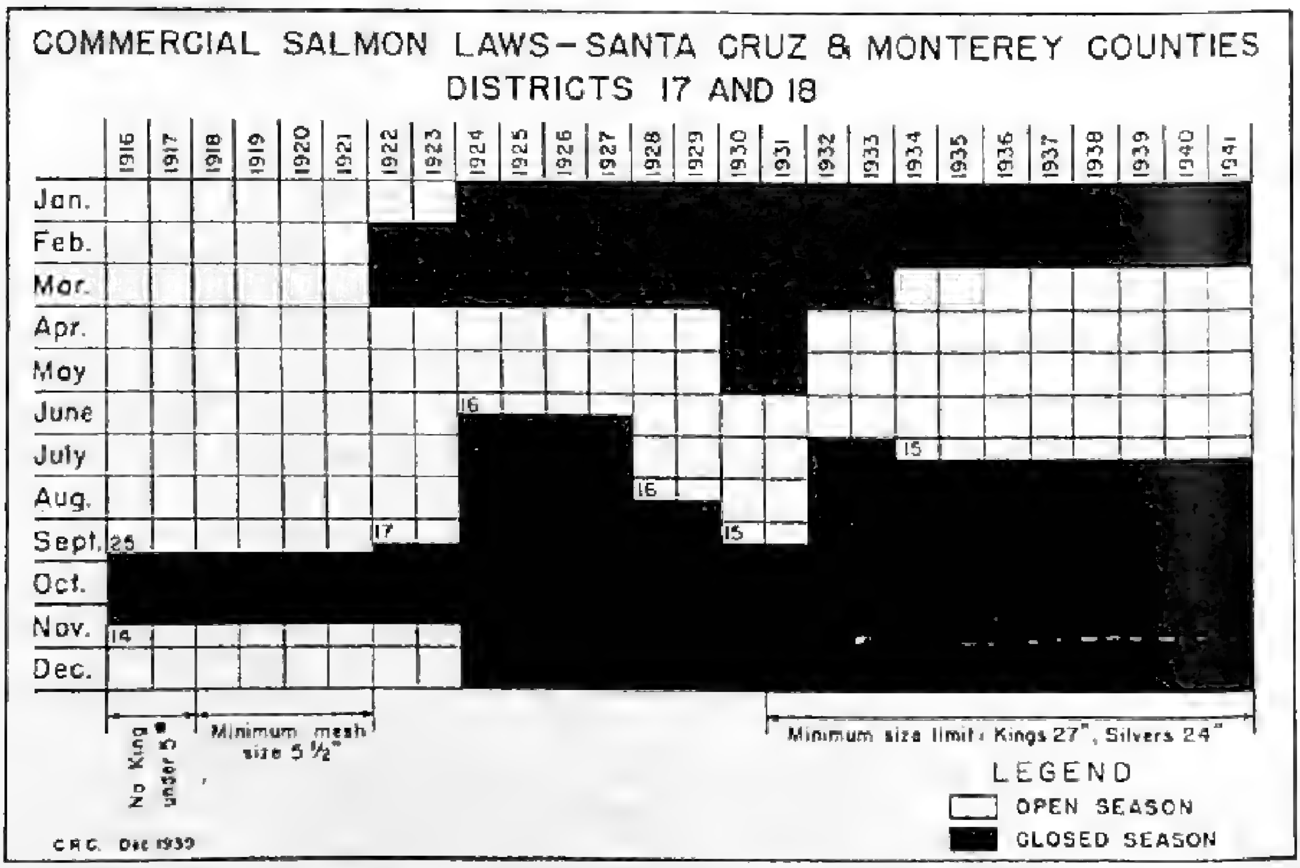

FIG. 26. Chart showing diagrammatically the changes in the commercial salmon laws in the Monterey Bay region from 1916 to 1941. Prior to 1916 there were no special laws for this region, and state-wide laws prevailed (see Fig. 23).

TABLE 1

Commercial Salmon Catch for Del Norte and Humboldt Counties by Months for the Years 1916 to 1930, Inclusive, Pounds

	1916	1917	1918	1919	1920	1921	1922	1923
January				263	818			
February						67		40
March								241
April			564	510	1,905			1,707
May	91	425	1,384	13,178	9,231	10,378	18,779	138,109
June	8,680	148		4,100	15,863	31,707	149,678	342,232
July	103,268	14,436	17,416	34,103	91,829	68,485	219,870	336,713
August	417,433	94,351	266,632	338,221	769,711	606,991	1,176,348	841,787
September	119,166	137,467	227,663	133,633	86,749	128,182	273,523	46,887
October	979,849	765,942	519,720	597,508	152,091	187,959	102,915	74,354
November	295,089	389,979	169,703	288,058	159,899	165,067	65,709	207,805
December	63,715	119,088	31,571	48,588	18,869	14,043		
Totals	1,987,291	1,521,839	1,234,653	1,458,162	1,307,568	1,212,879	2,006,822	1,990,235

	1924	1925	1926	1927	1928	1929	1930
January							
February	126			48			73
March				10			4,213
April		72,636	83,021	1,642			121,766
May	34,932	490,052	502,507	606,338		264,774	217,215
June	239,639	676,102	515,020	375,291	153,581	69,521	462,182
July	414,148	824,797	278,015	108,134	185,315	331,123	420,571
August	1,141,013	1,205,386	860,825	397,706	633,881	480,778	970,741
September	212,270	202,204	383,548	126,768	101,620	285,004	130,207
October	87,889	105,444	43,221	75,435	58,753	88,831	52,091
November	63,478	212,441	69,683	75,079	78,450	503	2,448
December	193						
Totals	2,193,688	3,795,062	2,825,840	1,856,451	1,211,600	1,520,624	2,387,507

TABLE 2

Commercial Salmon Catch for Mendocino and Sonoma Counties by Months for the Years 1916 to 1930, Inclusive, Pounds

	1916	1917	1918	1919	1920	1921	1922	1923
January	62		1,273					
February	8							
March								
April	890							
May			72		15,261	23,022	68,257	22,512
June	1,200	4,112	101,349	409,172	611,690	970,567	773,566	363,529
July	6	116,856	539,815	1,171,835	1,718,726	708,990	647,494	340,054
August	1,993	217,424	333,769	1,217,186	625,963	380,029	132,443	86,772
September		62,049	121,493	100,469	43,490	1,472		
October								
November	1,747	60						
December	1,748	49		941				
Totals	7,654	401,450	1,097,771	2,899,603	3,015,130	2,084,080	1,621,760	812,867

	1924	1925	1926	1927	1928	1929	1930
January							
February							
March							
April							215
May	19,581	9,286	42,436	62,200			
June	284,148	165,962	146,652	195,671	544,225	66,256	130,113
July	191,527	280,903	99,654	541,335	543,756	599,189	607,804
August	191,914	126,043	678,405	721,816	422,771	510,950	365,118
September	70		15,148	7,876	51,963	53,541	10,779
October							
November							
December							
Totals	687,240	582,194	982,295	1,528,898	1,562,715	1,229,936	1,114,032

TABLE 3

Commercial Salmon Catch for Sacramento River Districts by Months for the Years 1916 to 1930, Inclusive, Pounds

	1916	1917	1918	1919	1920	1921	1922	1923
January	14,996	20,037	47,228	53,591	33,017	14,664	11,776	23,774
February	44,107	48,974	69,119	86,045	40,012	45,551	29,228	35,716
March	76,784	101,550	131,402	124,829	158,875	125,460	108,138	49,426
April	173,465	160,076	268,087	263,832	265,859	273,520	179,768	173,701
May	471,831	464,991	480,776	662,874	704,782	409,869	233,873	213,337
June	186,453	104,215	70,762	97,053	73,244	125,239	108,081	114,278
July	165,112	169,266			167,822	134,248	100,451	163,082
August	502,038	640,130	573,265	550,447	691,414	607,498	334,832	437,480
September	1,730,060	2,156,119	4,204,425	2,488,383	1,700,127	753,758	573,799	992,447
October	94	5	6					
November	7,052	3,900	5,707	6,080	6,005	8,424	45,840	13,014
December	78,794	15,324	27,252	196,052	18,255	12,896	38,380	27,690
Totals	3,450,786	3,975,487	5,938,029	4,529,222	3,860,312	2,511,127	1,765,066	2,243,945

	1924	1925	1926	1927	1928	1929	1930
January	12,573	5,704	731	5,979	161	196	568
February	9,551	1,721	3,614	1,860	1,588	529	2,648
March	7,311	16,402	42,838	11,224	12,648	4,606	15,974
April	67,392	168,281	140,832	41,762	37,131	22,814	142,050
May	705,535	775,815	111,049	159,962	49,303	109,243	344,310
June	2,192		90,935	58,758	7,574	38,793	55,009
July							
August	331,588	471,051	246,866	233,306	126,183	139,582	169,141
September	1,408,207	1,328,614	571,405	404,674	317,228	263,182	480,659
October							
November	67,870	8,674	25,894	2,527	1,509	1,446	1,828
December	27,882	2,604	27,612	434	452	1,130	1,201
Totals	2,640,110	2,778,846	1,261,776	920,786	553,777	581,521	1,213,698

TABLE 4

Commercial Salmon Catch for San Francisco, Marin, and San Mateo Counties, by Months for the Years 1916 to 1930, Inclusive, Pounds

	1916	1917	1918	1919	1920	1921	1922	1923
January	468	680	2,218		692	43		75
February	551	1,171	166	99	294	30	20	286,753
March	202	170	6,710	1,547	16,255	112,599	203	717
April	231	15,289	138	20,336	5,901	52,079	1,432	21,265
May	859	6,106	34,689	18,590	2,621	5,849	4,564	32,113
June	62	4,434	411,001	34,082	17,341	73,338	390,260	504,370
July	45,579	8,464	1,001,059	403,050	611,889	577,155	481,061	399,146
August	107,599	567,854	120,526	700,093	755,771	66,956	63,136	23,954
September	107,158	675,516	351,196	263,317	49,053	49,786	18,481	43,895
October							6	51
November	19	276	255	253	51	294	237	907
December	161	352	836	1,341	64	757	1,017	1,622
Totals	262,889	1,280,312	1,928,794	1,442,708	1,459,932	938,886	961,317	1,314,877

	1924	1925	1926	1927	1928	1929	1930
January	5,119	43,636		271			
February	42,669	117,798	197	34			9
March	81,479	33,246	4,293	267	31		6,800
April	189,169	85,826	7,102	539			38,673
May	143,722	447,593	38,566	2,223	8,048	29,557	5,968
June	1,433,712	116,886	12,571	142,586	239,278	89,375	147,599
July	1,056,797	346,689	19,026	1,030,945	448,469	179,650	420,707
August	591,942	35,996	611,361	309,723	119,799	159,304	105,925
September	72,436	43,222	269,297	2,158	190	200,802	282,661
October		7					
November		37					
December							
Totals	3,617,045	1,270,936	962,413	1,488,746	815,815	658,718	1,008,242

TABLE 5

Commercial Salmon Catch for Monterey District by Months for the Years 1916 to 1930, Inclusive, Pounds

	1916	1917	1918	1919	1920	1921	1922	1923
January	3,085	34,491	62,784	2,418	2,323	161	10	
February	156,686	6,925	70,406	3,765	40,579	33,265		
March	216,443	522,600	187,777	211,934	104,235	146,850		
April	662,614	539,176	996,842	610,904	510,056	197,082	320,738	118,321
May	2,089,582	1,258,594	1,108,366	1,268,174	377,271	614,171	238,296	360,368
June	686,043	1,043,545	217,859	617,744	379,000	240,484	299,865	150,448
July	761,581	293,593	202,984	96,978	57,937	11,902	21,027	37,207
August	399,886	171,311	45,789	3,888	19,428	45	170	61,942
September	164,721	8,967		150	10		13	
October							10	
November	84,343	88		67				50
December	5,855	137	60		38			
Totals	5,230,839	3,879,487	2,892,876	2,816,022	1,490,877	1,243,960	880,129	728,336

	1924	1925	1926	1927	1928	1929	1930
January		32,917	48				
February		68,795					
March	1,689	246,932		1,244			
April	321,110	256,830	322	196,206	101,995	153,497	2,729
May	213,832	203,103	32,800	203,965	56,535	258,040	40,204
June	98,880	230,063	15,809	180,390	116,853	404,142	192,100
July	183,426	53,431	2,016	120,510	58,732	232,821	36,761
August	58,190	6,566	593	14,712	539	5,562	7,560
September	59	78	167			34	55
October							
November							
December							
Totals	877,186	1,098,715	51,755	717,027	334,654	1,054,096	279,409

TABLE 6

Commercial Salmon Catch for Region 10 by Months for the Years 1931 to 1939, Inclusive, Pounds

	1931	1932	1933	1934	1935	1936	1937	1938	1939
January	-------	-------	-------	-------	-------	-------	-------	-------	-------
February	-------	-------	-------	-------	-------	-------	-------	-------	-------
March	40	-------	-------	-------	-------	-------	-------	-------	-------
April	1,757	-------	-------	-------	12	10	-------	-------	181
May	15,770	50	1,062	5,403	7,959	850	4,521	523	1,415
June	27,502	3,274	14,409	38,533	5,866	9,255	218,453	37,406	39,468
July	30,899	2,434	41,594	44,390	40,925	81,252	347,340	140,068	32,205
August	55,331	3,734	8,100	10,273	128,048	26,863	218,460	14,251	57,963
September	9,079	5,958	4,151	3,598	29,088	1,180	67,530	25,173	66,974
October	-------	-------	-------	-------	-------	-------	-------	-------	-------
November	-------	-------	-------	-------	-------	-------	-------	-------	-------
December	-------	-------	-------	-------	-------	-------	-------	-------	-------
Totals	140,381	15,450	69,316	102,197	217,898	119,410	856,304	217,421	198,206

TABLE 7

Commercial Salmon Catch for Region 20 by Months for the Years 1931 to 1939, Inclusive, Pounds

	1931	1932	1933	1934	1935	1936	1937	1938	1939
January	-------	-------	-------	-------	-------	-------	-------	-------	-------
February	338	-------	-------	-------	-------	-------	-------	-------	-------
March	3,091	-------	-------	-------	-------	-------	-------	-------	-------
April	172,614	3,070	-------	214,824	170,521	111,194*	21,764	139,955	35,202
May	326,757	431,689	332,242	372,034	244,192	421,769	299,065	50,382	251,782
June	518,604	438,936	875,873	365,482	82,696	184,695	249,262	356,588	324,775
July	939,154	875,832	736,382	881,925	841,186	1,125,125	840,279	479,789	580,005
August	1,042,515	614,516	749,361	592,508	1,128,102	1,376,944	995,342	376,154	232,078
September	80,340	51,270	142,205	240,281	814,423	140,579	572,552	242,697	67,127
October	-------	-------	-------	-------	-------	-------	-------	-------	-------
November	-------	-------	-------	-------	-------	-------	-------	-------	-------
December	-------	-------	-------	-------	-------	-------	-------	-------	-------
Totals	3,083,413	2,415,313	2,836,063	2,667,054	3,281,120	3,360,306	2,978,264	1,645,565	1,490,969

TABLE 8

Commercial Salmon Catch for Region 30 by Months for the Years 1931 to 1939, Inclusive, Pounds

	1931	1932	1933	1934	1935	1936	1937	1938	1939
January	2,037	1,228	255	905	2,058	7,698	8,723	2,229	18,567
February	10,538	4,245	5,029	8,521	9,498	16,362	13,076	1,017	9,642
March	26,452	39,701	20,889	20,419	8,588	33,732	19,077	5,324	35,588
April	55,227	156,442	71,537	44,428	24,881	98,816	16,236	12,160	51,247
May	266,268	221,187	85,797	71,498	61,878	217,043	83,971	33,689	279,446
June	102,630	32,107	13,786	19,160	19,977	43,184	30,793	9,394	54,630
July	-------	-------	-------	-------	-------	-------	-------	-------	-------
August	159,294	160,102	88,498	51,770	167,080	153,201	268,588	160,778	3,075
September	318,661	648,234	168,462	180,841	594,003	378,143	532,381	1,429,714	9,900
October	-------	-------	-------	-------	-------	-------	-------	-------	-------
November	276	476	-------	11	495	20	49	2,160	2,581
December	222	-------	-------	-------	410	80	258	11,911	32,227
Totals	941,605	1,263,815	454,253	397,543	888,808	949,170	973,152	1,668,376	496,903

TABLE 9

Commercial Salmon Catch for Region 40 by Months for the Years 1931 to 1939, Inclusive, Pounds

	1931	1932	1933	1934	1935	1936	1937	1938	1939
January	--------	--------	--------	--------	--------	--------	--------	--------	--------
February	--------	60	--------	--------	--------	--------	--------	878	11,760
March	15,389	--------	--------	--------	--------	--------	--------	5,745	3,264
April	473	--------	--------	--------	--------	--------	--------	--------	--------
May	5,629	4,357	418	6,906	3,453	32,274	77,524	4,374	13,525
June	6,533	4,802	14,083	94,635	9,132	129,285	491,072	15,342	56,139
July	141,159	28,295	148,718	384,382	205,437	109,118	529,785	48,318	333,390
August	198,149	132,797	30,301	380,593	835,765	159,430	109,033	2,897	15,022
September	79,345	57,085	76	--------	--------	17,441	100	32,382	--------
October	--------	--------	--------	--------	--------	--------	--------	--------	--------
November	--------	--------	--------	--------	--------	--------	--------	--------	--------
December	--------	--------	--------	--------	--------	--------	--------	--------	--------
Totals	446,677	227,396	193,596	866,516	1,053,787	447,548	1,208,414	109,966	433,100

TABLE 10

Commercial Salmon Catch for Region 50 by Months for the Years 1931 to 1939, Inclusive, Pounds

	1931	1932	1933	1934	1935	1936	1937	1938	1939
January	--------	--------	--------	--------	--------	--------	--------	--------	--------
February	324	--------	--------	--------	--------	--------	--------	--------	--------
March	42	--------	--------	71,495	11,863	18,649	27,331	89	7,551
April	18,885	16,601	3,669	75,818	64,123	10,980	255,294	68,907	18,827
May	5,501	9,127	394,902	42,353	79,940	9,812	139,001	89,764	4,983
June	6,351	55,156	163,858	51,174	31,886	79,223	371,595	23,864	32,248
July	36,977	--------	7,430	45,390	31,888	26,260	97,862	16,850	61,876
August	24,701	--------	--------	--------	--------	--------	--------	--------	--------
September	38	--------	--------	--------	--------	--------	--------	--------	--------
October	--------	--------	--------	--------	--------	--------	--------	--------	--------
November	--------	--------	--------	--------	--------	--------	--------	--------	--------
December	--------	--------	--------	--------	--------	--------	--------	--------	--------
Totals	92,819	80,884	569,859	286,230	219,700	144,924	891,083	199,474	125,488

TABLE 11

Commercial Salmon Catches in Rivers of California, 1916–1939, Inclusive,* Pounds

	1916	1917	1918	1919	1920	1921	1922	1923
Smith River	161,430	50,785	74,828	85,114	7,729	72,079	92,161	285,100
Klamath River	801,150	265,537	672,345	535,198	872,295	614,247	1,039,580	824,291
Eel River	934,012	682,775	400,666	787,762	321,897	304,210	----------	----------
Sacramento River	3,450,787	3,975,487	5,938,029	4,529,222	3,860,312	2,511,127	1,765,066	2,243,945
Totals	5,347,379	4,974,584	7,154,542	5,937,296	5,062,233	3,501,663	2,896,807	3,353,336

	1924	1925	1926	1927	1928	1929	1930	1931
Smith River	186,014	309,289	146,912	261,462	171,657	108,212	81,417	19,766
Klamath River	814,572	956,082	811,714	408,081	308,826	321,502	622,129	666,299
Sacramento River	2,640,110	2,778,846	1,261,776	920,786	553,777	521,310	1,213,698	949,850
Totals	3,640,696	4,044,217	2,220,402	1,590,329	1,034,260	951,024	1,917,244	1,635,915

	1932	1933	1934	1935	1936	1937	1938	1939
Smith River	54,941	40,857	----------	----------	----------	----------	----------	----------
Klamath River	649,049	405,663	----------	----------	----------	----------	----------	----------
Sacramento River	1,265,050	447,646	401,667	888,888	953,959	973,152	1,668,376	496,903
Totals	1,969,040	894,166	401,667	888,888	953,959	973,152	1,668,376	496,903

* During this period, catches of salmon in the Mad River were made only in 1918, when 68,674 pounds were landed. Mad River figures appear in 1918 total.

TABLE 12

Commercial Salmon Catches Taken in Ocean Waters off California by Districts, 1916-1939, Inclusive, Pounds

	1916	1917	1918	1919	1920	1921	1922
Del Norte-Humboldt	90,699	522,742	12,840	50,039	100,251	216,179	875,081
Mendocino-Sonoma	7,654	401,450	1,097,771	2,899,603	3,015,130	2,054,080	1,621,760
San Francisco-Marin	262,889	1,280,312	1,928,794	1,442,708	1,459,932	938,886	961,317
Santa Cruz-Monterey	5,230,839	3,879,487	2,892,876	2,816,022	1,490,877	1,243,960	880,129
Miscellaneous	135	2,006	1,065	10	----------	----------	30
Totals	5,592,216	6,085,997	5,933,346	7,208,382	6,066,190	4,453,105	4,338,317

	1923	1924	1925	1926	1927	1928	1929
Del Norte-Humboldt	880,844	1,193,102	2,529,691	1,867,214	1,186,908	731,117	1,090,910
Mendocino-Sonoma	812,867	687,240	582,194	982,295	1,528,898	1,562,715	1,229,936
San Francisco-Marin	1,314,877	3,617,045	1,270,936	962,413	1,488,746	815,815	658,718
Santa Cruz-Monterey	728,336	877,186	1,098,715	51,755	717,027	334,654	1,054,096
Miscellaneous	----------	----------	----------	----------	21	5	----------
Totals	3,736,924	6,374,573	5,481,536	3,863,677	4,921,600	3,444,306	4,033,660

	1930	1931	1932	1933	1934	1935	1936
Del Norte-Humboldt	1,683,961	2,286,580	1,632,869	2,346,498	2,334,591	2,619,843	2,249,919
Mendocino-Sonoma	1,114,032	968,266	1,023,919	597,461	490,152	1,170,880	1,405,849
San Francisco-Marin	1,008,212	428,298	124,010	158,806	818,852	337,751	266,440
Santa Cruz-Monterey	279,409	91,471	80,884	569,859	286,230	219,700	144,924
Miscellaneous	6	----------	16	48	----------	15	1,020
Totals	4,085,650	3,774,615	2,861,698	3,672,675	3,929,825	4,348,190	4,068,152

	1937	1938	1939
Del Norte-Humboldt	3,337,162	1,438,230	1,553,142
Mendocino-Sonoma	558,705	430,476	268,789
San Francisco-Marin	1,108,402	94,975	285,194
Santa Cruz-Monterey	891,083	199,474	125,498
Miscellaneous	931	183	----------
Totals	5,896,283	2,163,338	2,232,623

TABLE 13

Total Commercial Salmon Catch, River and Ocean, 1916-1939, Inclusive, Pounds

	1916	1917	1918	1919	1920	1921	1922	1923
River catch	5,347,379	4,974,584	7,154,542	5,937,296	5,062,233	3,501,663	2,896,807	3,353,336
Ocean catch	5,592,216	6,085,997	5,933,346	7,208,382	6,066,190	4,183,105	4,338,317	3,736,924
Miscellaneous			5,300	49	5,396	6,164		
Totals	10,939,595	11,060,581	13,093,188	13,145,727	11,133,819	7,690,932	7,235,124	7,090,260

	1924	1925	1926	1927	1928	1929	1930	1931
River catch	3,640,696	4,044,217	2,220,402	1,590,329	1,034,260	951,024	1,917,244	1,635,915
Ocean catch	6,374,573	5,481,536	3,863,677	4,921,600	3,444,306	4,033,660	4,085,650	3,774,615
Miscellaneous								
Totals	10,015,269	9,525,753	6,084,079	6,511,929	4,478,566	4,984,684	6,002,894	5,410,530

	1932	1933	1934	1935	1936	1937	1938	1939
River catch	1,969,040	894,166	401,667	888,888	953,959	973,152	1,668,376	496,903
Ocean catch	2,561,698	3,672,675	3,929,825	4,348,199	4,068,152	5,896,283	2,163,338	2,232,623
Miscellaneous								
Totals	4,530,738	4,566,841	4,331,492	5,237,087	5,022,111	6,869,435	3,831,714	2,729,526

TABLE 14

Reported Sport Catch of Salmon, Pounds,* Charter Boats and Rented Skiffs Only

	1934	1935	1936	1937	1938	1939
Ocean off Crescent City						2,235
Smith and Klamath Rivers**	68,982	115,995	97,197	38,398	49,045	50,120
Ocean off San Francisco			873	12,728	34,122	51,580
Ocean off Monterey			1,458	3,520	570	1,527
Totals	68,982	115,995	99,528	54,646	83,737	105,462

* Blank spaces indicate no records available. 1939 figures subject to slight upward revision.
** Includes fish delivered to sport fish canneries, some of which is not caught from rented boats.

THE "N. B. SCOFIELD": A PROGRESS REPORT[1]

By H. C. Godsil
California State Fisheries Laboratory
Division of Fish and Game

A year ago, on December 17, 1938, the *N. B. Scofield* was launched. She was designed and built by the California Division of Fish and Game to secure the data needed for the understanding and intelligent administration of our marine fisheries. Hitherto, this information has been derived largely from the commercial catch. As the work progressed it became increasingly evident that the commercial catch could not supply all the material needed for the solution of our manifold problems. It was imperative to secure information from regions either not fished by the commercial fleet, or not fished at the desired season. We needed a boat that could catch fish where and when needed. The *N. B. Scofield* was therefore designed as a research vessel and equipped to catch any of the commercial species in California. Furthermore, three refrigerated fish-holds were incorporated in the design to experiment with the proper handling and stowage of fish, because the losses of tuna were assuming a magnitude of conservational importance. Thus dedicated to the investigation of the marine fisheries, the *N. B. Scofield* was commissioned in January, 1939, and has now been in service nearly a year. It seems appropriate, therefore, to examine at this time the performance of the vessel and see to what extent the results have justified the hopes of her sponsors.

In the calendar year of 1939, the *N. B. Scofield* made six extensive, investigative trips, in the course of which she ran in excess of 15,000 nautical miles. This distance has taken her from northern California to Central America in pursuit of different fisheries, following a carefully formulated and coordinated program embracing the most urgent aspects in each of the major fisheries. The entire program was fulfilled, with one exception, wherein it was necessary because of circumstances beyond our control to curtail the trip and eliminate the investigation of the flatfish populations in northern California.

In appraising the results of the remaining trips, it is necessary to bear in mind that the nature of the work precludes any final or sensational discoveries. The program is continuous, and each project necessitates a number of trips, often made in successive seasons, to yield the total body of information needed. Not until all data are accumulated, is it possible to issue a final report on any project, so that this summary of achievements is in the nature of a progress report, bringing our ultimate goal considerably closer to realization. Continued into the coming year the work of the *N. B. Scofield* will speedily result in milestones of definite accomplishments.

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[1] Submitted for publication, December 19, 1939.

Tuna

The stock of yellowfin tuna has been investigated in a number of localities to determine whether the fish throughout the fishing area constitute a single population. Samples were taken at a number of points along the Central American mainland—to supplement existing data—and subjected to a careful study to determine whether differences exist. Additional samples are yet needed from the most distant and insular grounds to complete this phase of the study. Work has also begun and material collected and prepared to determine the precise species of tuna existing on this coast. Throughout the years it has been assumed that our species is identical with the yellowfin found throughout the Pacific, but a doubt has always existed as to the correctness of this assumption This problem is of considerable administrative importance because it is essential to know the range (and so the abundance) of the species involved. This problem likewise will require another extensive trip to assemble all the material needed, and then a close comparison with specimens from other areas of the Pacific, which material has already been ordered.

Refrigeration

This problem involves the yellowfin tuna and skipjack. The main contribution of the *N. B. Scofield* thus far has been to divest the problem of all obscuring detail and reveal the essential features of the problem involved. Results of our work have been issued as preliminary recommendations to the industry, urging: (1) complete separation of the chilling and storage functions; (2) prompt chilling of the catch; (3) maintenance of uniform storage temperatures in the hold, said temperatures to be determined for various lengths of trips by our subsequent work; and (4) the adoption of minor recommendations involving detail and equipment. In conjunction with the work on refrigeration, a chemical method of measuring the quality of stored fish has been tried with promising results.

Albacore

One short trip was made in pursuit of albacore to determine whether there was any abundance of fish offshore at a time when they were scarce in the local fishing grounds. The *N. B. Scofield* went about 800 nautical miles off the coast to the Erben Bank, fishing continuously throughout the intervening distance. Albacore were found at a number of points, and an abundance of fish encountered on one day at an approximate distance of 350 miles off the coast. Some valuable refrigeration data were secured on this trip, pertaining to the rates of chilling and freezing of the catch at sub-zero (Fahrenheit) temperatures. The experience gained on this trip will be used to formulate a more comprehensive and intensive scouting program for 1940.

Sardines

The *N. B. Scofield* carried out an extensive and time-consuming survey of the young (small) fish populations throughout the entire rearing grounds. The coast line extending from central California southward into the Gulf of California was investigated. The purpose of the work was to appraise the magnitude of those groups of young

sardines which in the ensuing years will constitute the commercial catch. This work is essentially in the nature of a census: hence, it is of fundamental practical importance because, carried to completion, results will enable administrators to balance the output—the commercial take—against the ingress of young fish derived from successive spawnings. With the facilities of the *N. B. Scofield* we were able to obtain a large number of samples from desired localities, and approximate determinations were made of the relation between size and density of schools. A great deal of valuable information was secured incidentally pertaining to the size and distribution of young sardines encountered. Investigations were carried for the first time into the Gulf of California. An abundance of young sardines was encountered in this region in May, whereas in October no trace of these fish was to be found. The fate and identity of these fish has yet to be determined. In addition to the above survey, 5100 sardines were tagged and liberated in Mexican waters in the course of the several trips.

Mackerel

Lack of time prevented the *N. B. Scofield* from carrying out any extensive mackerel work in this year. The work planned was carried over into the program for 1940, and the first trip of the year will be southward to tag and investigate the populations of mackerel along the Mexican coast. However, in the course of other work observations were made on the occurrence of mackerel in the Gulf of California, and about 1000 mackerel were tagged at various points along the coast.

* * * * * * *

Incidental to the major program accomplished, a large number of observations were made concerning the distribution and abundance of fish of all species. Also, cumulative records have been kept regarding bait and bait grounds, with the view of compiling these at some future time for the benefit of all. Similarly, sea-water temperatures have been recorded throughout the work, which in the future will help to correlate seasonal runs of fish with prevailing ocean conditions.

It is with a sense of gratification that the State Fisheries Laboratory offers this progress report. In view of the fact that "fisherman's luck"—adverse weather or fishing conditions—can nullify the most carefully conceived plans, we are well satisfied with the progress made to date. The success is as much due to the efficient execution as to the sound formulation of the program, and in this regard we extend to Captain L. J. Weseth, Ralph W. Dale, Ellis Berry, Harry M. Peters, Peder Stockland, M. G. Stewart, Harry E. Rouch and William Nyland, our sincere appreciation of their sustained interest and hearty cooperation throughout the year. Likewise, to the officials of the Mexican and Costa Rican governments, we tender our thanks for the privilege of working unrestrictedly within their territorial waters, and we gratefully acknowledge the numerous courtesies extended to us.

TALL TALES OF THE SEA[1]

By W. L. Scofield
California State Fisheries Laboratory
Division of Fish and Game

The ocean and what is in it have always been something of a mystery because less has been known about the ocean than the land. Mysteries thrive best when no one knows the facts, for nothing is such a blight upon an interesting mystery as a general knowledge of the subject. When the facts are not available, or at least not known to very many people, we all can talk about the subject with greater freedom, unhandicapped by a knowledge of the facts, and it is like a return to the happy days of childhood when truth did not spoil exciting stories of giants and fairies. Whenever there is a mystery in good working condition, we feel safe in letting our imaginations run wild, and we can tell the most fantastic tales with fair assurance that we will be flattered and made to feel important by having our tall yarns believed. If no one knows the truth of the matter, no one is apt to spoil our fun.

What is under the surface of the land is not generally known, so here is the making of mystery, and we are sufficiently credulous to buy mining stock or oil shares because who knows—maybe the magic beans will grow into a vine that will carry us up into a rosy cloud of wealth and we can play the part of a modern streamlined "Jack and the Bean Stalk." Geologists have learned a good deal about what is underneath the surface, but there are only a few geologists and there is much that they have not learned yet, and so they only partly spoil our hopes while our will to believe leads us on to buy shares. Fortunately, for the mining stock salesmen we can't look beneath the surface so the gold might be there; at any rate we are anxious to believe it is.

We can not look beneath the surface of the ocean, and less is known about what is there than geologists have learned about the depths on land. Here then is the proper set-up for mystery, and the ocean has not disappointed us for it has mothered the most delightful fairy stories since men told tales or at any rate since the time when they learned to write them down on clay tablets and skins. Through all these years and right up to the present time, there have been plenty of believers of these yarns, and even now some tall stories are told and repeated because even though they may sound a little incredible, yet the facts in the case are not generally known and the audience accepts them without calling upon the speaker for proof of his statements. The story teller can do a really good job if he is never hampered by having to produce any evidence in support of what he tells.

So we have oft repeated sea stories plucked out of the thin air of unbridled imagination. For example, there is the one about sport fishing off the coast of southern California being so poor because there are 200,000 sea lions, each one of which eats daily twice his weight of game

[1] Submitted for publication, August, 1939.

fishes. Now we leave it up to you, if a sea lion weighs one-fourth of a ton, he would eat a ton of fish in two days, and in 365 days 200,000 sea lions would consume a right smart heap of fish. And, think what it would amount to during the last five years, but don't think about the hundreds of years sea lions have inhabited this coast and have been eating with fair regularity. We didn't intend to go into the question of how poor the sport fishing was hundreds of years ago because of the appetites of sea lions. That has no part in this story. There might be some hard-head in the audience who would wonder if sport fishing now in the ocean off southern California is really so poor, but such a kill-joy question would knock the props out from under the whole story and spoil it completely. The published census figures of the number of sea lions in the State and the records of what they eat and how much, are best not mentioned because, as has been intimated before, facts pollute the air of mystery and wreck the attitude of unquestioning acceptance which is so necessary to a story to make it thrilling.

Stop me if you have heard this one before, but do you know the one about kelp trimming destroying the spawn of game fishes, exterminating the beds and ruining sport fishing in the ocean? If you have read any of the reports on kelp harvesting during the World War and harbor doubts about fish spawning on the kelp, or trimming injuring kelp beds, you will be wise to keep such thoughts to yourself. If you voice them, you may be manhandled and at least you will be considered a deceiver and under suspicion of profiting in some way through the nefarious practice of kelp trimming. A pox upon you, enemy of fishermen!

Many of the fish stories about the ocean and the strange goings on in the sea have come to this coast ready made. They have been imported from abroad—starting in Europe or Asia, transplanted to our Atlantic seaboard, and then have migrated out to our west coast. Other stories are native sons, invented to shift the blame to someone else for real or imagined evils befalling one of our fisheries. Anything that happens or is assumed to happen in connection with ocean fishing must be explained, and since the facts so frequently are lacking a tall tale delivered with confidence and finality will explain for you just what it is that is supposed to have happened, and just how the dire condition came about along with the remedy that will correct the evil if the misdeeds of someone else are sufficiently curtailed. Thus, we have a host of ingenious explanations for a real or fancied shortage of fish, and the blame for the assumed scarcity is placed upon anything or anyone rather than upon the fishermen engaged in that fishery.

Before we can explain *why* something happens, it is desirable to find some proof that the thing really happened, but it is rather curious to observe that where there is evidence to indicate a shortage of fish, the facts and the shortage are so frequently denied in the face of the proof. Yet, almost as frequently, there is grave concern over the depletion of some fish when all proof of decreasing abundance is lacking. Of course, the remedy for all this is to accumulate more facts and a more general spreading of the known facts among the members of the fishing fraternity. Dependable facts and tested knowledge about the ocean and its inhabitants usually are not easily arrived at nor quickly, but result only after carefully recorded observations repeated over a period of

years. That is why so few of them are available, but there is no shortage of undependable misinformation and there is little indication that this supply is suffering depletion.

Whales are mysterious animals and stories of their strange influence over fishes have come to this State from northern Europe by way of New England. We can all agree that the long continued slaughter of whales has resulted in their scarcity in all the seas where they have been hunted. Starting with this, you can explain almost any change in fisheries during the same years. Increasing scarcity of whales and declining abundance of salmon in old England, New England or California are self-evident, so slaughter of whales caused salmon depletion. It is only necessary to point out that the two events occurred—no proof is required that one caused the other. This is convenient, for we need no longer bother about overfishing, power dams, reduced spawning beds or unscreened irrigation ditches interfering with salmon.

If you prefer to deny depletion of salmon, you can explain the misleading apparent scarcity by the lessened abundance of whales. An intelligent and experienced salmon man explained this to me. Whales were so reduced in number that they no longer were driving the salmon into Monterey Bay where the trollers could get them. He had seen whales drive schools of salmon but he could not explain how he knew the whales were driving and not following the salmon. He admitted the salmon were feeding on anchovies at the time, but he denied that the whales were following the anchovies. The likelihood that the whales were pursuing their favorite food and paying no attention to the salmon that happened to be about was beside the point and did not explain the fact that salmon trollers in Monterey Bay were making increasingly poorer catches year after year. The scarcity of whales did explain it; at least it did to the satisfaction of my salmon man till I asked the foolish questions about following and feeding, thereby casting doubt upon a perfectly good story. Such conduct was not good cricket on my part, and I can only plead in my defense that I was twenty years younger then and had even less good sense than at present. Whales also are said to drive sardines wherever they choose and other fishes as well, in Europe and here, but the whale advocates admit that no other animal, including man, is able to drive schools of fish any distance in a definite direction in the open ocean.

Another story imported from the North Sea into our Atlantic states and later to the Pacific Coast is the destruction of fish spawn by drag or trawl nets. The story has been told and believed for generations in several parts of the world and it explains whatever you wish to have explained. You are not expected to mention the fact that practically no fish eggs are deposited on the bottom of the sea and that if eggs were there they would pass through the mesh of the nets. People making nets for fish eggs use a small mesh, preferably bolting silk or fine screening such as is used in flour mills. Why this story should center on fish spawn is probably due to the fact that it started that way and merely has been handed on through the years. If the story could be changed to tell of the destruction of small-sized fish, it would have some facts to support it, but as we have noticed before, facts spoil the story.

Naval battle practice scaring the fish out of the region is another European importation told and believed even when statistical evidence is pitted against the yarn, but again we admit that it is unfair to organized stories to drag in statistics, and the examples already given will serve to indicate the persistence and geographical migrations of some of the tall tales. There are many that have persisted since very early times wherever fishermen have depleted the fish supply in any limited area. It seems that a reduced supply of fish is seldom if ever the fault of fishermen, but rather is the result of some change such as altered ocean currents, an upset in the balance of Nature, different climatic conditions during recent years, a shift in the prevailing winds or a change in the seasonal run of the fish.

Needless to say, no dependable evidence is necessary to support any one of these claims, and often the alibi is a credit to the inventive genius of man. For that matter, we are all rather adept at shifting the blame to some one else and when we can pin the responsibility on an act of Nature, such as changing the ocean currents, that leaves us all in the clear. It proves beyond doubt that there is no need to regulate fishing operations, as that will not help matters, because the root of the evil lies in the change brought about by Nature herself and nothing we can do will remedy that.

Fishes are unaccountable creatures and a seeming scarcity readily may be explained by a change in the habits of the fish themselves. They run at a different season of the year than was customary in the good old days. If fish appear to be scarce, it is because they are running later than they used to, or maybe they find it desirable to run earlier in the year; it all depends upon the circumstances necessary to allay fears of depletion. The changeable nature of fishes is most obvious when there is a legal period closed to fishing, for then the fish abandon their former feeding and spawning habits and besport themselves only during the closed season. The remedy for this sad state of affairs is to open the closed season at once and then we would find that fish were as plentiful as ever they were in former years. If the run seems to be made up of smaller individuals than in the past it means that the big ones are running later (or earlier) when fishermen are not so apt to catch them, and the prevalence of small fish is not to be explained by depletion causing a reduced average size of fish in the catch. Then there is the story of the big fish becoming boat-shy, hook-shy, or man-shy, so that they shy away from being caught as of yore, in spite of the assertion that they congregate in the waters somewhere in their former abundance.

The central idea in these stories is to show that there is no overfishing. However, there are a few instances when scarcity of fish is too obvious to be explained away, and in these cases the fault rests upon some other class of fishermen or some new fishing gear recently introduced or the method of fishing employed by the other fellows. Starting with any one of these variations as a base, a few personal observations and experiences can be added to dress up a really good and authentic yarn. Basically, many of these stories are the same, but there is the spice of variety in the harrowing details that make an old yarn almost new.

In one English town, the committee of elders investigating the decreased salmon run in the local stream, placed the blame upon the addition of a tall spire to the village church, but that story was not very successful—not that it was illogical, but it smacked too much of jealousy and dissension within the church fold over the construction of the spire in the first place. We happen to know more about small town jealousies than we do about salmon, and so we smell a mouse in this otherwise good story.

A local version of a good story was spoiled by poor telling. A commercial fisherman of San Pedro explained the summer scarcity of mackerel one year on the ground that the "water was too dry." He meant the rainfall the previous winter did not send down to the ocean enough fresh water in the streams to attract the mackerel. Don't ask if fresh water attracts mackerel, that is not part of the tale. The point is that he was using a time-tested alibi, but his faulty English damaged the story almost to the point of ruining it, and we might have missed his meaning if we had not heard the same story in past years applied to salmon and sardines and had read several versions of it by European authors. He, no doubt, heard the story as a boy back in the old country and probably could have done it justice in his mother tongue. Incidentally, the next winter this same fisherman maintained that poor fishing was due to too much rainfall, an error on the part of Mother Nature which must have resulted in the water being too "wet" for mackerel. A good story teller has absolutely no need of that rare jewel "Consistency" but he really should possess a ready flow of English.

So here's to bigger and better sea stories! May the world be made safe for the teller of tales and never let it be said that a good yarn was spoiled for mere truth's sake!

EDITORIALS AND NOTES

RETIREMENT OF N. B. SCOFIELD

N. B. Scofield, Chief of the Bureau of Marine Fisheries, retired from the service of the California Division of Fish and Game on November 30, 1939, after over 40 years of creditable work in furtherance of conservation.

In behalf of Mr. Scofield's co-workers, I wish to express their sincere regrets at the necessity of his leaving this Division. We have all been honored by the association of men such as Mr. Scofield with the Division and respect the honor he has brought by his years of outstanding service and accomplishment.

At the December, 1939, meeting of the Fish and Game Commission, Mr. Kenneth I. Fulton, in behalf of the Governor and the Commission, presented a scroll to Mr. Scofield embodying the following resolution:

"WHEREAS, N. B. Scofield has reached 70 years of age, has completed 42 years of outstanding service in the employ of the Fish and Game Commission of the State of California, and

"WHEREAS, Mr. Scofield has served the State with such outstanding success, his accomplishments being too numerous to mention covering the fields of fisheries research, legislation and administration,

"*Now, Therefore, be it Resolved,* We, the undersigned members of the Fish and Game Commission, do hereby wish to express to Mr. Scofield our sincere appreciation of his years of service, loyalty, sincerity and unfailing support and encouragement.

CULBERT L. OLSON,
Governor,
State of California,

Nate F. Milnor,

Kenneth I. Fulton,

Edwin L. Carty,

Germain Bulcke,

Lee F. Payne."

In addition, the veteran employees of the Division tendered Mr. Scofield a farewell dinner and all past and present members of the California State Fisheries Laboratory joined in sending him a letter of tribute.

In the January, 1939, issue of this magazine appeared an article on the accomplishments of Mr. Scofield in his many years of valuable service in marine fisheries conservation work in California. In recognition, the newly built fisheries research vessel of the Division was named the "N. B. Scofield."—*Lester A. McMillan, Executive Officer, California Division of Fish and Game.*

TWENTY-FIVE YEARS AGO IN "CALIFORNIA FISH AND GAME"

An article in the January, 1915, issue of "California Fish and Game" relates the reasons for the enactment of California's first angling license law which provided that sport fishermen as well as hunters and commercial fishermen should pay their share of the cost of maintaining fishing. Prior to 1911 appropriations from the State's general fund supported fish hatcheries and other fish conservation work. During 1911, 1912 and 1913, this work was carried on with the money derived from hunting and commercial fishing licenses. This was obviously unfair to the hunters who expected their license fees to go toward improvement of hunting conditions. Although we now take it for granted that fishermen should pay for the privilege of using the natural resources of the State, there was considerable opposition to the angling license act at first.

In another article, the rise and decline of the fishery for catfish in the Central Valley is described. Catfish were introduced to California in 1874 and increased remarkably. However, there were no restrictions on fishing until 1909, by which time catfish had been all but exterminated.

The death in 1914 of the last surviving passenger pigeon was noted —a milestone in the history of wildlife destruction that helped to spur the campaign for conservation. Other species have been wiped out by man and others no doubt will be in the future, but with the widespread improvement in conservation practices, we can look forward to having less "horrible examples" of destruction than in the days of the pioneers.—*Richard S. Croker, Editor, California Fish and Game.*

APPEARANCE OF BLACK BRANT AT SAN QUENTIN BAY, LOWER CALIFORNIA

During a recent sardine survey cruise of the California Division of Fish and Game research vessel, *N. B. Scofield,* along the Lower California coast, watch was also kept for any migratory game birds that might be seen. On October 27, 1939, we went into San Quentin Bay with the motor launch. At least six black sea brant were seen in the lower reaches of the bay. There may have been more farther up the slough, but this area was not scouted due to lack of time. A number of ducks were also seen. The only ones that could be identified were a flock of about thirty canvas-backs. Turtle Bay and Magdalena Bay were also visited and scouted on October 11 and October 25, 1939, respectively, but no ducks or brant were seen on either visit.—*J. A. Aplin, California State Fisheries Laboratory, Division of Fish and Game, December, 1939.*

PRIBILOF FUR SEAL ON CALIFORNIA COAST

The wise policy of giving protection to the Pribilof fur seal [1] by taking only a part of the annual increase, has resulted in a gratifying increase in numbers of this species as is commonly known. This increase is reflected in the greater frequency with which individuals,

[1] *Callorhinus ursina cynocephala* (Walbaum) would appear to be the correct name for the Pribilof fur seal, commonly designated as *Callorhinus alascanus* Jordan and Clark (see Stejneger, "Georg Wilhelm Steller * * *," Harvard University Press, 1936, p. 285).

by accident, come ashore in California. More are seen now than say 35 years ago and apparently they come ashore in even greater numbers a few hundred miles farther north, when the migrations to and from the breeding grounds are under way. A recent instance of this kind is that in which a cow fur seal came ashore a few miles north of Crescent City, Del Norte County, California, on May 25, 1939. Although given every possible care in the Crescent City Aquarium where it was placed because of its weakened condition, the animal died on May 31. When dissected no sign of injury was found. It was, however, "very thin"; no fat was found. The animal (California Museum of Vertebrate Zoology, acc. no. 5884) weighed 56 pounds and measured, in millimeters, as follows: Length from tip of nose to tip of tail, 1182; length of tail vertebrae after skinning, 130; length of hind foot, 280; length of ear, 40.—*E. Raymond Hall, California Museum of Vertebrate Zoology, Berkeley.*

TRANSPLANTATION OF THE DOUGLAS GROUND SQUIRREL

The Beechey ground squirrel (*Citellus beecheyi beecheyi*) and the Douglas ground squirrel (*Citellus beecheyi douglasii*) are said by persons having experience with both animals to differ in habits important to man, and in degree of response to control measures as well as in appearance because of their different pattern of coloration. Therefore, and because of the possibility of modification of the native fauna, it is well to record a transfer of Douglas ground squirrels into the range of the Beechey ground squirrels, and subsequent escape of the alien animals, as so often results from attempts to maintain private zoos. Under date of November 18, 1939, Max J. Leonard, Agricultural Commissioner of San Mateo County, California, wrote me as follows:

"In 1935 the three boys of the C. E. Johnson family, residing at 1220 Douglas Avenue, Burlingame, spent the summer at Lakeport on Clear Lake, Lake County * * * the boys trapped one dozen squirrels and brought them home * * *. Late in the fall of that same year, a dog tore the screening from the cage and all the squirrels escaped * * *. Half a block from this address (1220 Douglas Avenue) a drainage creek runs unimpeded to the Bay through open country, which had a substantial squirrel population at that time. Presumably the escaped animals found this creek and followed it into the open country between Burlingame and the Bayshore highway * * *. From specimens taken in this area in 1938 and the spring of 1939, it seems there is a distinct cross between *douglasii* and *beecheyi* in regard to coat markings."—*E. Raymond Hall, California Museum of Vertebrate Zoology, Berkeley.*

A NORTHERN RECORD FOR A CENTRAL AMERICAN POMPANO

A Central American pompano, *Chloroscombrus orqueta*, was taken on September 15, 1939, near Los Angeles Harbor in a haul of live bait. Mr. T. V. Carter noticed the fish and brought it to the California State Fisheries Laboratory for identification. Magdalena Bay, Lower California, was the former northern record.—*D. H. Fry, Jr., California State Fisheries Laboratory, Division of Fish and Game, September, 1939.*

REVIEWS

North American Big Game

Compiled by Alfred Ely, H. E. Anthony and R. R. M. Carpenter. A publication of the Boone and Crockett Club, published under the auspices of the National Collection of Heads and Horns of the New York Zoological Society. New York, Charles Scribners, 1939. 533 pp., illus. $7.50.

In one sense this new work is a sequel to the familiar "Records of North American Big Game" which appeared in 1932. It goes further than "Records," however, and deals comprehensively with all of the species of big game found on the North American continent today. The book is the work of many authors. More than thirty naturalists and sportsmen have made contributions that have enabled the editors to present all of the sides of a many-sided subject.

The book opens with a brief discussion of the big game of Pleistocene North America, followed by a chapter entitled "Vanishing Game" that enumerates the species of big game that have been extirpated, or practically so, since the arrival of the white man on this continent.

Ensuing chapters deal with a variety of subjects and contain much practical information on arms, photography, hunting with the bow and arrow, and the preparation of specimens. An entire chapter is devoted to each of the species of big game, including the description, distribution, and a section devoted to hunting. The paragraphs on hunting, written by experienced sportsmen, make fascinating reading. They are full of true stories of the chase and just plain stories of the chase—some amusing, some thrilling, and all interesting.

The book is profusely illustrated with photographs of record heads, line drawings and diagrams. The last part of the book is devoted to a tabulation of the measurements of record heads.

The editors of this book have done a fine job, by and large, and we can find it in our hearts to forgive certain inaccuracies and most of the bias, for it is essentially a popular work. We are not, however, going to forgive the author of chapter II for referring to the "official killers" of mountain lions in California as an "evil brotherhood." Mr. Shoemaker apparently refuses to countenance the killing of big game unless the killing is done by the Earl of Dunraven. We make Mr. Shoemaker feel uncomfortable.—*Gordon H. True, Jr., California Division of Fish and Game.*

Strange Fish and Their Stories

By A. Hyatt Verrill. Boston, L. C. Page & Co., 1938. 220 pp., illus. $2.50.

Mr. Verrill has added another very readable volume to his series of "Strange Stories from Nature." The book is replete with charming, well written accounts of strange fish, many of them bordering on the fantastic. There are twenty-one chapters, each describing fish with some unusual claim to fame, such as: fish who build nests, fish that

climb trees, ogres of the deep, kissing fish, living nightmares of the deep seas, not to mention a section on fishes that never existed and some mysterious facts about various fishes. All the stories are entertaining and the author has evidently tried to keep them authentic. All in all, this is a remarkable collection of stories and should prove to be something of a reference work as well as an idle hour companion. Being a "popular" book there is no bibliography. There are two full-page color plates and numerous black and white drawings.

Perhaps it is not amiss to call attention to the strangest story of all: In his introduction, Mr. Verrill states that there has been no diminution in the numbers of fish in the sea; "all that man has taken, all that are daily destroyed by birds, predatory fish, seals and whales and other creatures have made little if any impression upon the numbers of fish in the oceans." However, we know that many species of fish are scarcer and that depletion of many species is serious—in fact, on page 104, Mr. Verrill tells us that some kinds of sharks have been overfished to the point of depletion!

However, the book is good reading. Since its publication, another in the "Strange stories" series has made its appearance—"Strange animals and their stories."—*Richard S. Croker, Editor, California Fish and Game.*

The Migration and Conservation of Salmon

Edited by Forest Ray Moulton; publication committee, A. G. Huntsman (chairman), Henry B. Bigelow, Frank R. Lillie. American Association for the Advancement of Science Publication no. 8, 106 pp., 1939.

On June 29, 1938, many of the leading scientists whose work has been on the Atlantic and Pacific salmons met in Ottawa, Canada, to participate in a symposium on these fish under the auspices of the American Association for the Advancement of Science. The papers which were read, as well as the discussion held on the following day, have been published in the volume under review. The following men contributed papers: W. J. M. Menzies (Some preliminary observations on the migrations of the European salmon); David L. Belding (The Atlantic salmon of the Gulf of St. Lawrence); A. G. Huntsman (Migration and conservation of Atlantic salmon for Canada's maritime provinces); Willis H. Rich (Local populations and migration in relation to the conservation of Pacific salmon in the western states and Alaska); W. A. Clemens, R. E. Foerster and A. L. Pritchard (The migration of Pacific salmon in British Columbia waters); Henry B. Ward (Factors controlling salmon migration); and Edwin B. Powers (Chemical factors affecting the migratory movements of the Pacific salmon).

Each of the contributing authors is an expert in his field and each paper represents the ideas of the author on one or more extremely important phases of salmon life-history and conservation. An adequate review of the symposium is not possible without going into great detail —all we can say is that anyone interested in salmon from any viewpoint can not afford to miss this collection of controversial papers.—*Richard S. Croker, Editor, California Fish and Game.*

In Memoriam

ROBERT L. SINKEY

It is with deep regret that the Division of Fish and Game makes known the death on December 5, 1939, of one of our "pioneer" employees, Warden Robert L. Sinkey, who at all times performed his duties so efficiently and conscientiously. His many friends within the ranks of the Division will miss him greatly. He was very well thought of in his territory in Yolo County, where he worked for almost thirty years, with headquarters at Woodland.

Warden Sinkey entered the service of the Division of Fish and Game on December 1, 1911, and had been employed continuously since then until November 1, 1939, when he retired on physical disability as he had been ill for some time. He ordinarily would have retired on December 1, 1939, at the age of 70.

When only ten years old, while hunting near Woodland, a shotgun shattered his right arm, necessitating amputation, but despite this handicap he was able to handle a gun very effectively, making high scores in trap shoots, and to drive without any difficulty an automobile as well as a motorcycle in the early days.

To his wife, Mrs. Edna Sinkey, and to his two children, Mrs. Doris C. Karstaedt and Maynard Sinkey, we wish to express our sincere sympathy over their loss.—*E. L. Macaulay, Chief, Bureau of Patrol and Law Enforcement.*

REPORTS

STATEMENT OF REVENUE

For the Period July 1, 1939, to September 30, 1939, of the 91st Fiscal Year

	Detail	Subtotal	Total
Revenue for Fish and Game Preservation Fund:			
License Revenue—			
1939 series, angling:			
Citizen	$265,338 00		
Less sales refunded to ineligible licensees	—20 00		
Net citizen	$265,318 00		
Nonresident	3,516 00		
Alien	3,180 00		
Duplicate	238 50		
Total angling		$272,252 50	
Commercial hunting club, citizen		75 00	
Commercial hunting club, operator, citizen		25 00	
Deer tags		55,953 00	
Fish breeders		30 00	
Fish packers and wholesale shell fish dealers			
Citizen	$765 00		
Alien	40 00		
Total fish packers and wholesale shell fish dealers		805 00	
Fishing party boat permits		52 00	
Fish tags		1,115 02	
Game breeders		102 50	
Game tags		142 41	
Hunting			
Citizen	$141,618 00		
Less sales refunded to ineligible licensees	—4 00		
Net citizen	$141,614 00		
Alien	1,050 00		
Declarent alien	1,480 00		
Duplicate	139 50		
Nonresident	740 00		
Junior	8,019 00		
Total hunting		153,042 50	
Market fishermen	$21,690 00		
Less sales refunded to ineligible licensees	—20 00		
Net market fishermen		21,670 00	
Trapping			
Citizen	$45 00		
Alien	2 00		
Total trapping		47 00	
Total 1939 series			$505,341 93
1938 series, angling:			
Citizen	$3,378 00		
Nonresident	3 00		
Duplicate	1 50		
Total angling		$3,382 50	
Deer tags		1,735 00	
Hunting			
Citizen	$12,542 00		
Less sales refunded to ineligible licensees	—2 00		
Net citizens	$12,540 00		
Duplicate	27 50		
Junior	767 00		
Total hunting		13,334 50	
Market fishermen		10 00	
Trapping, citizen		110 00	
Total 1938 series			$18,572 00

STATEMENT OF REVENUE

For the Period July 1, 1939, to September 30, 1939, of the 91st Fiscal Year—Continued

	Detail	Subtotal	Total
Revenue for Fish and Game Preservation Fund—Continued:			
License Revenue—Continued			
1937 series, angling			
Citizen	$3,298 00		
Alien	100 00		
Duplicate	7 00		
Total angling		$3,405 00	
Deer tags		1,284 00	
Hunting			
Citizen	$6,076 00		
Junior	425 00		
Duplicate	10 00		
Nonresident	250 00		
Declarent alien	—10 00		
Total hunting		6,751 00	
Trapping, citizen		72 00	
Total 1937 series			$11,512 00
1932 series, hunting		$87 35	
1928 series, angling		645 68	
1928 series, deer tags		10 00	
1928 series, hunting		2,971 00	
Total 1928 and 1932 series			3,714 03
Other revenue:			
Court fines		$14,576 04	
Fish packers tax		22,031 44	
Kelp harvesters tax		91 35	
Miscellaneous revenue		1,330 35	
Salmon packers tax		4,976 68	
Total other revenue			43,005 86
Total current year			$582,145 82
Prior year, 90th			
1938 series, angling:			
Citizen	—$35 00		
Duplicate	6 00		
Nonresident	8 00		
Alien	15 00		
Total angling		—$6 00	
Fish importers		—5 00	
Fish packers and wholesale shell fish dealers		35 00	
Hunting			
Citizen	—$16 00		
Duplicate	1 50		
Junior	21 00		
Nonresident	30 00		
Total hunting		36 50	
Trapping, citizen		—2 00	
Total prior year, 1938 series			58 50
1937 series, hunting			
Citizen	—$18 00		
Junior	—18 00		
Total hunting		—$36 00	
Trapping, citizen		1 00	
Fish packers and shell fish dealers		—30 00	
Total prior year, 1937 series			—65 00

STATEMENT OF REVENUE

For the Period July 1, 1939, to September 30, 1939, of the 91st Fiscal Year—Continued

	Detail	Subtotal	Total
Revenue for Fish and Game Preservation Fund—Continued:			
89th fiscal year			
1938 series, angling			
Citizen	—$871 50		
Alien	685 00		
Duplicate	—6 50		
Nonresident	—39 00		
Total angling		—$232 00	
Fish packers and wholesale shell fish dealers		—35 00	
Fish importers		5 00	
Fish tags		—1,767 24	
Game tags		—161 34	
Hunting			
Citizen	—$18 00		
Junior	—18 00		
Total hunting		—36 00	
Market fishermen		420 00	
Total prior year, 1938 series			—$1,806 58
1937 series, angling			
Citizen	$722 00		
Nonresident	39 00		
Alien	—550 00		
Total angling		$211 00	
Deer tags		—3 00	
Game tags		161 34	
Fish tags		1,767 24	
Fish packers and shell fish dealers		30 00	
Hunting			
Citizen	—$11 00		
Junior	12 00		
Total hunting		1 00	
Market fishermen		—120 00	
Trapping, citizen		—2 00	
Total prior year, 89th, 1937 series			1,745 58
Grand total all years, Fish and Game Preservation Fund			$582,078 32

STATEMENT OF EXPENDITURES

For the Period July 1, 1939, to September 30, 1939, of the 91st Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Operating Expenditures—91st Fiscal Year					
Administration:					
Cashier	$480 00				$480 00
Executive	1,249 98	$7 69	$516 82		1,774 49
Exhibits			1,250 00		1,250 00
General office	1,891 29	365 54	6,457 38	$69 79	8,784 00
Library	500 00	81	39 00	43 13	582 94
Property inspection	780 00	58 16	54 78		892 94
Publicity			1,086 38		1,086 38
Total Administration	$4,901 27	$432 20	$9,404 30	$112 92	$14,850 75
Patrol and Law Enforcement:					
Cannery inspection	$2,563 96		$77 94		$2,641 90
Executive	3,720 00	$17 85	382 36	$514 19	4,634 40
General office	1,375 81	65 46	72 01	73 17	1,586 45
Junior patrol	1,020 00	26 45	164 23		1,210 68
Land patrol	53,073 02	2,745 27	14,787 65	4,471 76	75,077 70
Marine patrol	20,125 28	4,356 88	8,525 67	2,687 28	35,695 11
Pollution patrol	2,807 42	228 91	991 00	508 08	4,535 41
M. V. Bluefin galley		82 16			82 16
N. B. Scofield galley		61 12			61 12
Total Patrol and Law Enforcement	$85,585 49	$7,584 10	$25,003 89	$8,255 48	$126,428 96
Marine Fisheries:					
Central Valley Water Project Study	$2,117 74	$185 93	$1,149 80		$3,453 47
Executive	1,905 00		87 87		1,992 87
Field supervision	825 00	21 31	270 70		1,117 01
Fish cannery auditing			580 65		580 65
General office	3,115 57	9 87	309 03		3,434 47
Research and statistics	13,018 07	444 63	2,849 85	$271 10	16,583 65
Total Marine Fisheries	$20,981 38	$661 74	$5,247 90	$271 10	$27,162 12
Fish Conservation:					
Biological survey	$2,949 00	$173 94	$432 37	$71 64	$3,626 95
Executive	1,740 00	3 98	87 39		1,831 37
Fish food unallocated		7,052 51	663 84		7,716 35
Fish planting	1,804 54	243 07	1,089 32		3,137 83
Fish rescue	3,425 83	168 84	1,225 46		4,820 13
Field supervision	1,380 00	26 73	403 87		1,810 60
General office	1,275 00	237 70	9 06		1,521 76
Pollution inspection	1,155 00	51 90	248 95		1,455 85
Statistical	600 00	3 71	343 22		946 93
Structural maintenance	1,080 00	51 38	388 39		1,519 77
Alpine Hatchery	1,022 74	372 90	72 70		1,468 34
Basin Creek Hatchery	1,055 49	129 61	98 95		1,284 05
Benbow Dam Exp. Station	680 00		52 05		732 05
Big Creek Hatchery	375 00	53 78	82 80		511 58
Blue Lakes Egg Col. Station	330 00	2 93			332 93
Brookdale Hatchery	710 49	192 83	78 82		982 14
Burney Creek Hatchery	1,441 77	118 67	77 60	6 15	1,644 19
Central Valleys Hatchery	962 50	238 08	421 91	19 89	1,643 01
Copco Egg Col. Station		30 48			30 48
Cottonwood Lakes Egg Col. Station			4 00		4 00
Experimental Hatchery	450 00	31 51	24 04		505 55
Fall Creek Egg Col. Station	1,520 65				1,520 65
Fall Creek Hatchery		217 66	79 40	10 45	307 51
Feather River Hatchery	1,663 07	317 65	228 18		2,208 90
Fern Creek Hatchery	789 52	78 84	100 04		968 40
Forest Home Hatchery	1,191 61	738 28	203 38		2,133 27
Fort Seward Hatchery	621 67	39 46	5 00		666 13
Heenan Lake Egg Col. Station		24 77		2 83	27 60
Hot Creek Hatchery	1,165 48	888 80	134 06	58 30	2,246 64
Huntington Lake Hatchery	1,207 10	444 38	312 65		1,964 13
Kaweah Hatchery	1,161 77	266 85	490 19		1,918 81
King Salmon			1 00		1 00
Kings River Hatchery	590 96	89 18	128 56		808 70
Klamathon Egg Col. Station	568 53	108 98	7 24	90 13	774 88
Lake Almanor Hatchery	1,518 87	281 69	102 14		1,902 70
Lytle Creek Hatchery			20 00		20 00
Madera Hatchery	378 39	222 54	272 72		873 65
Marlette Lake Egg Col. Station	56 00				56 00
Mount Shasta Exp. Hatchery			870 41		870 41

STATEMENT OF EXPENDITURES

For the Period July 1, 1939, to September 30, 1939, of the 91st Fiscal Year—Continued

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Fish Conservation—Continued:					
Mount Shasta Hatchery	$9,424 87	$3,199 73		$121 59	$12,746 19
Mt. Tallac Hatchery	1,070 00	473 01	$44 88		1,587 89
Mt. Whitney Hatchery	3,808 30	786 51	821 78	210 44	5,627 03
Mountain Home Hatchery	1,230 00	469 13	360 00		2,059 03
Prairie Creek Hatchery	1,838 66	414 29	245 84	8 22	2,507 01
Scott Creek Egg Col. Station	405 00	14 27	28 00		447 27
Shasta River Egg Col. Station	182 95	15 45			198 40
Snow Mountain Egg Col. Station			1 00		1 00
Tahoe Hatchery	1,699 00	240 16	46 40		1,985 62
Waddell Creek Station			1 40		1 40
Yosemite Hatchery	1,195 16	387 68	93 05		1,675 89
Yuba River Hatchery	961 61	149 08	59 28		1,169 97
Total Fish Conservation	$56,686 53	$19,051 44	$10,471 33	$599 64	$86,811 91
Hydraulics:					
Engineering	$1,984 85	$102 69	$713 28		$2,800 82
Executive	1,020 00	42 10	139 85		1,201 95
General office	430 00	1 24	25 83	$87 83	544 90
Total Hydraulics	$3,434 85	$146 03	$878 96	$87 83	$4,547 67
Game Conservation:					
Deer damage control	$275 41	$31 86	$178 94		$486 2
Duck rescue	468 26	48 28	364 67	$337 10	1,218 3
Elk Refuge	420 00	66 70	53 66		510 3
Executive	2,175 00	109 93	591 63	459 77	3,339 3
Game management	1,889 65	81 90	377 18	690 66	3,039 4
General office	780 00	15 01	3 55	6 06	804 62
Grey Lodge Refuge	1,140 00	115 21		1,099 56	2,354 77
Imperial Refuge	494 94	49 95	38 92		583 81
Los Banos Refuge	1,131 61	143 72	75 95	546 69	1,897 97
Predatory animal lion hunters	1,565 00	34 48	1,421 35	1,406 05	4,426 88
Predatory animal trapping	6,454 26	705 84	1,258 46	30 00	8,448 56
Refuge posting		345 57			345 57
Research	1,285 00	145 97	394 79	690 66	2,516 12
Statistics	585 00	85 80	318 22		989 02
Suisun Refuge	768 39	105 40	69 87	24 02	967 68
Total Game Conservation	$19,432 55	$2,085 62	$5,150 19	$5,290 57	$31,958 93
Game Farms:					
Executive	$870 00		$169 52		$1,039 52
Game Bird Distribution, Yountville	2,149 03	$59 56	504 49		2,713 08
Game Bird Distribution, Los Serranos		68 53	24 36		92 89
General office	289 03				289 03
Los Serranos Boarding House			16 33		16 33
Los Serranos Game Farm	2,967 39	779 49	566 94	$92 68	4,406 50
Yountville Boarding House	234 35	317 99	28 08		580 42
Yountville Game Farm	3,681 87	1,433 93	586 71	706 60	6,409 11
Total Game Farms	$10,191 67	$2,659 50	$1,896 43	$799 28	$15,546 88
Licenses:					
Executive	$870 00	$16 72	$60 54		$947 26
General office	180 00	34 84	42 34	$57 32	314 50
License distribution	3,083 23	8,160 38	22,241 24		33,484 85
Total Licenses	$4,133 23	$8,211 91	$22,344 12	$57 32	$34,746 61
Other Current Expenses:					
Maintenance and construction of fish screens and other stream improvements					
Fish screens	$5,063 28	$1,081 09	$303 73	$410 86	$6,858 96
Stream improvements, Granlees Dam Fishway Project	1,173 32	1,068 43	74 85	2 46	2,319 06
Stream improvement overhead		17 10	10 50	116 26	143 86
Stream improvement, Sheep Camp Lake Project			20 00		20 00
Total Other Current Expenses					$9,341 88

STATEMENT OF EXPENDITURES

For the Period July 1, 1939, to September 30, 1939, of the 91st Fiscal Year—Continued

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Special Item:					
Appropriation to pay claim of Department Accounting Officer, Department of Finance, 91st Fiscal Year, Chapter 1046–39				$393 61	$393 61
Total Operating Expenditures 91st Fiscal Year					351,789 35
Contributions to Employees Retirement System, 91st Fiscal Year					2,602 90
Expenditures for Additions and Betterments:					
Purchase of game refuges and public shooting grounds and construction, improvements and equipment:					
Improvements	$760 93	$15 00			775 93
Total Current Year, 91st Fiscal Year					$355,168 18
Prior Bennium:					
90th Fiscal Year for Support Not Closed				$38,418 23	
89th Fiscal Year for Support Not Closed				—4 91	
Total 89th and 90th Fiscal Years for Support Not Closed					$38,413 32
Additions and Betterments:					
Purchase of game refuges and public shooting grounds and construction improvement and equipment, 90th Fiscal Year, not closed					2,402 58
Contributions to Employees' Retirement System, 90th Fiscal Year					5,217 92
Grand total, 89th and 90th fiscal years					46,033 82
Grand total					$401,202 00

GAME CASES

July, August, September, 1939

Offense	Number arrests	Fines imposed	Jail sentences (days)
Bear: Closed season, in refuge, no permit	2	$115 00	45
Deer: Failure to tag, possession spike buck, doe, spotlighting, possession closed season, no license, possession fawn, allowing dogs to run deer, venison in possession, selling	213	12,625 00	1,389½
Doves: No license, overlimit, closed season, shooting from automobile, before 7 a.m.	114	2,322 00	360
Ducks: Possession closed season, before 7 a.m., sale, taking eggs, overlimit, shooting from automobile	11	255 00	
Firearms: Possession in refuge, discharge in refuge	44	1,390 00	80
False statement to obtain license	3	45 00	
Geese: Overlimit, possession closed season	1	25 00	
Gun club: Operating without license	1		25
Heron: Taking	1	25 00	
Hunting: No license, closed season, night, failure to show license	42	852 00	125
Nongame bird: Possession	4	75 00	25
Pheasants: Overlimit, closed season, female, shooting from automobile, operating snares	43	2,357 50	30
Pigeons: Closed season, bandtail	1	10 00	
Quail: Closed season, no license	13	320 00	19
Rabbits: Possession cottontails, brush, closed season, no license, shooting from automobile, spotlighting	37	725 00	30
Sagehen: Closed season	2	50 00	
Shooting: Early, from highway	7	125 00	
Transfer license	4	70 00	
Totals	543	$21,380 50	2,137½

FISH CASES

July, August, September, 1939

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalone: Possession, undersized, red, green, black, out of shell, overlimit, closed season, no license	27	$645 00	
Angling: No license, closed stream, failing to show license, false statement to obtain license, refuge, closed season, at spillway of dam, other than with hook and line	81	1,362 00	228
Bass: Possession black, calico, striped, white sea, undersized, overlimit, closed season, night buying or selling, no license, other than with hook and line	66	1,975 00	180
Bluegill: Possession, overlimit, closed season	13	255 00	
Catfish: Selling, closed season, undersized	1	25 00	
Clams: Undersized, overlimit, closed season, Pismo, selling, razor, Washington	20	470 00	295
Cockles: Overlimit	3	75 00	
Commercial Fishing: No license, no boat numbers, no records	83	2,605 00	270
Crabs: Possession, undersized, female, closed season	1		30
Frogs: Overlimit, undersized	1	25 00	
Lobsters: Closed season, undersized, overlimit	5	250 00	42
Nets: Operate in closed waters, purse seine, closed waters	38	3,300 00	30
Minnows: Selling, no license	1	25 00	
Perch: Taking from closed stream, no license	2	25 00	
Pollution	32	3,855 00	
Salmon: Overlimit, undersized, night	8	95 00	
Spear: Within 300 ft. stream	3	175 00	
Transfer license	9	235 00	5
Set lines	3	175 00	
Trout: Overlimit, taking during closed season, no license, closed area, undersized eastern brook, rainbow, steelhead, selling, prohibited gear, other than with hook and line held in hand	33	910 00	
Yellowfin: No license, undersized	1	100 00	
Obstructing stream to fish	1	100 00	
Totals	432	$16,652 00	1,080

SEIZURES OF FISH AND GAME

July, August and September, 1939

Fish:	
Abalone	236
Barracuda, lbs.	2,289
Bass, black	42
Bass, black, lbs.	4½
Bass, striped	38
Bass, striped, lbs.	99½
Catfish	25
Catfish, lbs.	20
Clams, Pismo	928
Carp	13
Cockles	429
Crappie, lbs.	12
Halibut, lbs.	217
Lobsters	60
Lobsters, lbs.	100
Mullet, lbs.	150
Perch	54
Salmon	13
Salmon, lbs.	574
Sardines, tons	50
Sea-bass, white	1
Sea-bass, white, lbs.	2½
Sunfish, bluegill	15
Sunfish, bluegill, lbs.	36
Traps, bass	1
Fish—continued:	
Traps, lobster	5
Trout	1
Trout, lbs.	51
Trout, eastern brook	95
Trout, rainbow	8
Tuna, yellowfin, lbs.	4,725
Game:	
Bear meat, lbs.	10
Deer	49
Deer hide	2
Deer meat, lbs.	430
Doves	106
Ducks	11
Herons	1
Honkers	2
Pheasants	38
Pigeons	1
Quail	18
Rabbits	60
Sagehen	1
Teal, blue wing	1
Tree squirrel hide	2
Turkeys, wild	2

COMMERCIAL FISH LANDINGS IN CALIFORNIA BY FISHING BOATS

July, 1939

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	California waters								Waters south international boundary		Total landings by fishing boats
	*Regions 10 and 20, Del Norte and Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total pounds	Region 70, Los Angeles	Region 80, San Diego	
Anchovy				2,455		8,810		11,265			11,265
Barracuda						171,109	138,581	309,690			309,690
Cabezone				15				15			15
Cabrilla									8,315	5,493	13,808
Carp		529						529			529
Catfish		5,700						5,700			5,700
Cultus, Pacific	35,881		10,244	6,123		7	35	52,290			52,290
Flounder, Starry	11,550		16,915	1,240			93	29,798			29,798
Flying Fish					68	3,797		3,865			3,865
Grouper										5,734	5,734
Hake	395		2,250					2,645			2,645
Halibut, California	1,370		704	10,735	26,210	26,892	5,293	71,204		49,999	121,203
Halibut, Northern	103,147		21					103,168			103,168
Kingfish			10	24,507	40	9,223		33,780			33,780
Mackerel, Horse				17,304		50,005	1,280	68,589			68,589
Mackerel, Pacific				33,817	1,059	2,523,501	1,515,229	4,073,606			4,073,606
Perch	1,382		3,632	6,286	49	286		11,635			11,635
Pompano, California				2		11		13			13
Rock Bass					3,004	25,579	31,501	60,084		670	60,754
Rockfish	72,232		11,700	81,212	8,208	14,547	35,210	223,109		1,580	224,689
Sablefish	82,643		1,050	10,469		5,498		99,660			99,660
Salmon	611,852		333,390	61,886				1,007,128			1,007,128
Sand Dab	22,042		60,313	12,166		394		94,915			94,915
Sardine			186,500	199,330		13,495	559	399,884			399,884
Sculpin						11,157		11,157			11,157
Sea-bass, Black					1,364	947	323	2,634	7,560	51,482	61,676
Sea-bass, White				108	490	12,651	38,226	51,475	37	7,704	59,216
Shark	4,800	67,100	147,789	422,753	449,635	37,312	11,932	1,141,330			1,141,330

Sheepshead					245	251		496			496
Skate	12,610		7,364	3,021	1,496	501		24,992			24,992
Smelt	2,439		13,489	12,506	901	3,415		32,750		140	32,890
Sole	342,171		253,596	30,900	48,155	618	76	681,516			684,516
Swordfish, Broadbill					17,785	65,387	26,854	110,026	21,909	79,812	211,747
Tuna, Albacore					11,912	503,689	8,505	524,106			524,106
Tuna, Bluefin					7,005	1,921,154	536,008	2,464,167	216,567	24,301	2,705,035
Tuna, Bonito					203	31,322	103,211	134,736	98,771	2,823	236,330
Tuna, Skipjack									2,527,725	1,333,502	3,861,227
Tuna, Yellowfin						61	20	81	5,190,154	6,475,344	11,665,579
Turbot			8,610	100				8,710			8,710
Whitebait	14,844		1,035	51				15,930			15,930
Whitefish, Ocean					180	19		199		127	326
Yellowtail						504	29,027	29,531	109,061	288,536	427,128
Miscellaneous Fish	13,915		2,938	425	396	1,893	5	19,572		463	20,035
Crustacean:											
Crab	271,532		427,980	2,402				701,914			701,914
Crab, Rock						469		469			469
Shrimp			106,125	5				106,130			106,130
Mollusk:											
Abalone				81,975	178,175	737		260,887			260,887
Clam, Cockle			19			1,624		1,643			1,643
Clam, Gaper			434					434			434
Clam, Pismo					20,339			20,339			20,339
Clam, Razor	40							40			40
Clam, Soft-shell	23		6,871					6,894			6,894
Clam, Washington			377					377			377
Octopus	44		195	2,613	61			2,913			2,913
Oyster, Eastern			5,015					5,015			5,015
Oyster, Japanese			63,040		2,788			65,828			65,828
Oyster, Native			2,727					2,727			2,727
Squid				185,015				185,015			185,015
Total pounds	1,601,912	73,338	1,764,333	1,218,421	779,798	5,446,835	2,481,968	13,369,605	8,180,099	8,327,710	29,877,414

*The eight geographical regions of the State are as follows:
Regions 10 and 20, Del Norte and Eureka: Del Norte, Humboldt and Mendocino counties.
Region 30, Sacramento: Sacramento and San Joaquin River systems with the delta areas, including Suisun Bay and Lake County.
Region 40, San Francisco: Sonoma, Marin, San Francisco and San Mateo counties, including San Francisco and San Pablo bays.
Region, 50, Monterey: Santa Cruz and Monterey counties.
Region 60, Santa Barbara: San Luis Obispo, Santa Barbara and Ventura counties.
Region 70, Los Angeles: Los Angeles and Orange counties.
Region 80, San Diego: San Diego and Imperial counties.
These tables are subject to slight revision due to belated supplemental items.

COMMERCIAL FISH LANDINGS IN CALIFORNIA BY FISHING BOATS

August, 1939

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	California waters								Waters south international boundary		Total landings by fishing boats
	*Regions 10 and 20, Del Norte and Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total pounds	Region 70, Los Angeles	Region 80, San Diego	
Anchovy			1,000	1,250		10,686		12,936			12,936
Barracuda					110	124,835	202,405	327,350		2,076	329,426
Cabezone				329	9			338			338
Cabrilla									6,689		6,689
Catfish		4,885						4,885			4,885
Cultus, Pacific	43,184		10,913	3,939				58,036			58,036
Flounder, Starry	48,220		32,006	123				80,349			80,349
Flying Fish					13	5,699		5,712			5,712
Hake	115		345					460			460
Halibut, California			856	5,534	30,570	13,513	208	50,681		14,233	64,914
Halibut, Northern	6,282							6,282			6,282
Kingfish				5,769	4	8,241	56	14,070			14,070
Mackerel, Horse				10,308		14,841		25,149			25,149
Mackerel, Pacific	18			58,375	365	5,767,954	766,610	6,593,322			6,593,322
Mullet							165	165			165
Perch	360		5,287	901	7,026	2,141	245	15,966			15,966
Pompano, California				55		42		97			97
Rock Bass					7,786	13,218	21,050	42,054			42,054
Rockfish	50,259		14,633	69,629	6,224	4,711	12,655	158,111			158,111
Sablefish	157,634		3,112	280		3,803		164,829			164,829
Salmon	279,014	3,075	15,957					298,046			298,046
Sand Dab	28,485		53,489	5,852	7	79		87,912			87,912
Sardine			293,900	78,475		44,114	855	417,344			417,344
Sculpin						9,179	1,934	11,113			11,113
Sea-bass, Black					712	1,186	1,123	3,021	61,933	51,859	116,813
Sea-bass, White				22,019	529	7,317	32,948	62,813	57	1,279	64,149
Sea-trout, California				13				13			13
Shark	338	127,437	376,241	360,097	15,609	9,227	177	889,126			889,126

Sheepshead					405	1,697	19	2,121			2,121
Skate	9,230		13,322	792	1,633	815		25,792			25,792
Smelt	3,869		15,791	15,097	705	8,249		43,711			43,711
Sole	313,413		392,508	507	7,388	163	83	714,152			714,152
Swordfish, Broadbill					28,740	64,558	11,344	101,648	43,910	90,321	238,879
Tuna, Albacore	2,922		2,156	917,702	86,054	924,885	96,388	2,030,107	500	3,010	2,033,617
Tuna, Bluefin					2,628	3,243,166	303,325	3,549,119	200,136	25,241	3,834,496
Tuna, Bonito					5,002	938,957	162,425	1,106,474	2,007,639	33,355	3,207,468
Tuna, Skipjack						21,800	58,755	80,555	1,013,817	1,925,588	3,049,960
Tuna, Yellowfin					38	4,357	19,529	23,924	5,786,424	10,018,081	15,828,429
Turbot			13,191					13,191			13,191
Whitebait	9,653		846	7				10,506			10,506
Whitefish, Ocean						145	1,144	1,589			1,589
Yellowtail						490	20,892	21,382	140,781	169,565	331,728
Miscellaneous Fish	9,225		5,073	17	237	1,025	14	15,591			15,591
Crustacean:*											
Crab	186,766		303,702	50				490,518			490,518
Crab, Rock						20		20			20
Shrimp			114,793					114,793			114,793
Mollusk:											
Abalone				115,350	137,050	413		252,813			252,813
Clam, Cockle						743		743			743
Clam, Gaper			380					380			380
Clam, Pismo					16,661			16,661			16,661
Clam, Razor	20							20			20
Clam, Soft-shell	12		6,610					6,622			6,622
Clam, Washington			184					184			184
Octopus				1,995				1,995			1,995
Oyster, Eastern			5,686					5,686			5,686
Oyster, Japanese			73,723					73,723			73,723
Oyster, Native			1,880					1,880			1,880
Squid				30,565				30,565			30,565
Total pounds	1,149,025	135,397	1,757,584	1,705,120	355,601	11,252,269	1,714,640	18,069,645	9,411,886	12,334,608	39,816,139

* See footnote to table for July.

COMMERCIAL FISH LANDINGS IN CALIFORNIA BY FISHING BOATS

September, 1939

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	California waters								Oregon and Washington waters		Waters south international boundary		Total landings by fishing boats
	*Regions 10 and 20, Del Norte and Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total pounds	Region 70, Los Angeles	Region 80, San Diego	Region 70, Los Angeles	Region 80, San Diego	
Anchovy			637			166,646		167,283					167,283
Barracuda					16,531	57,262	77,329	151,122				126,722	277,844
Cabezone				138	9			147					147
Carp		380						359					389
Catfish		35,815				22		35,837					35,837
Cultus, Pacific	22,362		30,971	1,075	7	81		54,496					54,496
Flounder, Starry	24,700		128,540	108	471			153,819					153,819
Flying Fish						3,879		3,879					3,879
Grouper												1,556	1,556
Hake	100		2,839					2,939					2,939
Halibut, California			1,115	955	35,590	8,093	4,065	49,818				20,667	70,485
Halibut, Northern	6,862							6,862					6,862
Kingfish				8,549	88	17,696		26,333					26,333
Mackerel, Horse				7,740		438,455		446,195					446,195
Mackerel, Pacific				350,232	6,151	7,555,118	77,425	7,988,926					7,988,926
Mackerel, Spanish											55	125	180
Mullet						78		78					78
Perch	64		5,832	164	96	849		7,005					7,005
Pike		23						23					23
Pompano, California				8		397		405					405
Rock Bass					1,166	2,865	5,936	9,967				1,493	11,460
Rockfish	48,453		40,927	21,102	7,249	7,706	3,094	128,531				12,976	141,507
Sablefish	151,050		525	162		4,112		155,849					155,849
Salmon	127,754	9,900						137,654					137,654
Sand Dab	4,530		70,471	2,111		127		77,239					77,239
Sardine			443,600	46,867,636		122,173	974	47,434,383					47,434,353
Sculpin					16	4,653	948	5,617					5,617
Sea-bass, Black					140	744	716	1,600			25,734	10,606	37,940

Sea-bass, White			8,082	39,629	69,022	68,011	16,476	201,220				96,354	297,574
Shark	9,223	272,003	263,963	36,941	5,576	25,786	8,620	622,202			35		622,237
Sheepshead					768	1,005		1,773				637	2,410
Skate	4,190		25,701	586	1,569	813		32,862					32,862
Smelt	6,040		8,067	9,469	438	10,452	116	34,582					34,582
Sole	165,400		487,665	2,272	14,158	191	11	669,700					669,700
Split-tail		20						20					20
Swordfish, Broadbill					25,466	28,373	10,686	64,525				27,182	91,707
Tuna, Albacore			231,406	2,831,639	720,771	124,355	699	3,908,870	793,151	424,012		677	5,126,740
Tuna, Bluefin					91	180,645	8,271	189,013			13,510	4,664	207,187
Tuna, Bonito				11	12,366	1,263,800	7,519	1,283,696			646,022	55,553	1,985,271
Tuna, Skipjack					10	147,497	1,355,896	1,503,403			1,616,848	2,019,392	5,139,643
Tuna, Yellowfin						35,250	198,380	233,630			1,887,043	4,933,197	7,054,770
Turbot			21,651					21,651					21,651
Whitebait	795		784					1,579					1,579
Whitefish, Ocean						73		73				1,735	1,808
Yellowtail						3,663	4,592	8,255			283,537	106,273	398,065
Miscellaneous Fish	3,038		5,313	60	502	8,905	124	17,942					17,942
Crustacean:													
Crab	11,700							11,700					11,700
Shrimp			104,999					104,999					104,999
Mollusk:													
Abalone				88,650	222,700	251		311,604					311,604
Clam, Cockle			4			626		630					630
Clam, Gaper			240					240					240
Clam, Pismo				1,631	15,803			17,434					17,434
Clam, Soft-shell	60		5,532					5,592					5,592
Clam, Washington	2,819		101					2,923					2,923
Octopus	185			522				707					707
Oyster, Eastern			9,831					9,831					9,831
Oyster, Japanese			109,497					109,497					109,497
Oyster, Native			428					428					428
Squid				42,945				42,945					42,945
Total pounds	559,325	318,240	2,008,727	50,314,335	1,156,757	10,290,658	1,781,880	66,459,922	793,151	424,012	4,473,684	7,419,809	79,570,608

* See footnote to table for July.

SHIPMENTS OF FRESH FISH FROM OTHER STATES AND FOREIGN COUNTRIES

July, 1939

	Oregon and Washington	Gulf of California	Japan
For canneries:			
Tuna, Albacore	----------	----------	775,548
For fresh fish markets:*			
Cabrilla	----------	1,410	----------
Sea-bass, Totuava	----------	25,212	----------
Total pounds	----------	26,622	775,548

August, 1939

	Oregon and Washington	Gulf of California	Japan
For canneries:			
Tuna, Albacore	121,507	----------	131,306
Tuna, Skipjack	----------	----------	39,941
For fresh fish markets:*			
Cabrilla	----------	1,455	----------
Total pounds	121,507	1,455	171,247

September, 1939

	Oregon and Washington	Gulf of California	Japan
For canneries:			
Tuna, Albacore	1,823,659	----------	88,408
Tuna, Bluefin	44	----------	----------
Tuna, Skipjack	----------	----------	57,893
Total pounds	1,823,703	----------	146,301

* This record includes only that fish which is voluntarily reported to the Division of Fish and Game and does not represent all shipments.

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Motor Vessel *Bluefin*, Terminal Island
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printed in CALIFORNIA STATE PRINTING OFFICE
SACRAMENTO, *1940* GEORGE H. MOORE, STATE PRINTER